UNIVERSIDAD PARA LA COOPERACIÓN INTERNACIONAL
(UCI)

PROJECT MANAGEMENT PLAN FOR THE RAILWAY LINE EXTENSION IN WASHINGTON, D.C.

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FINAL GRADUATION PROJECT SUBMITTED IN PARTIAL FULFILLMENT OF
THE REQUIREMENTS FOR THE
MASTER'S IN PROJECT MANAGEMENT (MPM) DEGREE

SAN JOSÉ, COSTA RICA
DECEMBER, 2020

APPROVAL PAGE

UNIVERSIDAD PARA LA COOPERACIÓN INTERNACIONAL

(UCI)

This Final Graduation Project was approved by the University as partial fulfillment of the requirements to opt for the Master's in Project Management (MPM) Degree

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DEDICATION

Dedicated to all the daily metrorail commuters who enjoy traveling, without whom the Dulles metrorail is impossible.

To the ones who found joy standing on the station platform to see that train coming with hope to finally get home to their loved ones after tiring days.

To the ones who created friendships, love stories, and relationships

To the students who used the commute time to do their last-minute exam preparations.

To the ones who enjoyed the diversity of people and pets on the train while sipping their coffee.

To the ones who found a seat only to sleep.

To the ones who fought for the seat to relish the scenic view.

To the ones who enjoyed the burst of music, ignoring the chaos.

To the ones who get lost on the metro station even after their 100th travel…

Nikita Saran

"Among individuals working more than 40 hours a week, commuting more than an hours each way to work on a typical day was associated with a 30% higher risk of having an inactive lifestyle and a 18% higher risk of sleep problems, the study found. After a tiring day at work and long hours of commute, people may not be physically active. Daily routine of most adults' is determined by their work routines, including how much time they spend getting to and from their jobs. While long work hours have been previously linked to unhealthy behaviors like inactivity, smoking and poor eating habits, the study dives deep into the reasoning of the combined effect of excessive work and endless commutes over time".

– NYC Times, n.d.

ACKNOWLEDGMENTS

My gratitude goes to my amazing mentor and professor: Osvaldo Martínez, all my teachers throughout this course, and to the UCI management for providing this opportunity and wonderful journey throughout this course.

I am very grateful for this prospect and dedicated to utilize the knowledge gained in my career advancement, which I have gained through this degree program.

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ABBREVIATIONS AND ACRONYMS

ADA: Americans with Disabilities Act of 1990

AFC: Automatic fare collection

ARS: Adopted regional system

ATC: Automatic train control

CAO: Contract administration officer

CAPRA: Capital reserve account

CO: Contracting officer

COTR: Contracting officer's technical representative

CPM: Critical path method

CTB: Commonwealth Transportation Board

DBE: Disadvantaged business enterprise

DIAAH: Dulles International Airport access highway

DRPT: Department of Rail and Public Transportation

DTE: Dulles transit engineers

DTP: Dulles transit partners

DTR: Dulles toll road

EA: Environmental assessment

EEO: Equal employment opportunity

EIS: Environmental impact statement

ENCP: Office of engineering and capital projects (WMATA)

ENSS: Engineering support services (WMATA)

ES&H: Environmental, safety, and health

FAA: Federal aviation administration

FFGA: Full Funding Grant Agreement

FGP: Final graduation project

FF: Finish to finish

FS: Finish to start

FTA: Federal transit administration

GEC: General engineering consultant

HOT: High occupancy toll

LLC: Limited liability corporation

LPA: Locally preferred alternative (Dulles Corridor Metrorail Project)

MCAP: Major capital projects (WMATA)

MIS: Major investment study

MOT: Maintenance of traffic

MOU: Memorandum of understanding

NATM: New Austrian tunneling method

NEPA: National Environmental Policy Act of 1969

NTP: Notice to proceed

OPER: Department of operations

OMB: Office of management and budget

OSHA: Occupational safety and health administration

PE: Preliminary engineering

PFC: Passenger facility charges

PICO: Post-Installation check-out

PMSS: Project management support services

PMOC: Program management oversight consultant

PMP: Project management plan

PPEA: Public-Private Education Facilities and Infrastructure Act of 2002

PPTA: Public-Private Transportation Act of 1995

PMBOK® Guide: Project Management Body of Knowledge Guide

PMI: Project Management Institute

PM: Project management

PMP: Project management plan

PR: Puerto Rico

GBRRP: Gurabo Bank River Restoration Project

RBS: Risk breakdown structure

RFI: Request for information

ROD: Record of decision

ROW: Right-of-Way

RAMP: Real estate acquisition management plan

SF: Start to finish

SS: Start to start

SCC: Standard cost categories

SCIL: Safety/Security certifiable items list

SCMP: System safety/security certification management plan

SCRC: Safety and Security Certification Review Committee (WMATA)

SCWG: Safety/Security certification working group

SSMP: Safety and security management plan

STR: Senior technical representative

TAB: Technical advisory budget

TEAM: Transportation electronic award management

TMP: Transportation management plan

TOC: Tri-State Oversight Committee

VDOT: Virginia Department of Transportation

WBS: Work breakdown structure

WFCY: West Falls Church Yard

WMATA: Washington Metropolitan Area Transit Authority

EXECUTIVE SUMMARY

Bechtel Infrastructure Inc. was founded in the year 1898. The company is focused on delivering world-class customer experience and has completed more than 25,000 projects in 160 countries on all seven continents. It has created jobs, grown economies, improved the resiliency of the world's infrastructure, increased access to energy, resources, and vital services, and made the world a safer, cleaner place. Betchel Infrastructure has thoroughly reviewed and constantly updates risks and uncertainties to the program to identify “scope creeps,” schedule slippage, and cost increases. Aggressive risk assessment and change management is paramount to success. Effective communication with affected communities and agencies to ensure minimal impact to the existing local transportation network, the local commercial economy, and the social fabric of the community. Bechtel Infrastructure Inc provides full transparency in the procedures to be executed in the construction of the Dulles Corridor Metrorail Project along with the DTP (Dulles transit partners) and aims to complete the work and accounts for progression through the life of the contract.

To meet the compliance and communication with FTA (federal transit administration) project management oversight requirements and best practices in accordance with the Section 5309 New Starts program and specific terms and conditions within the executed FFGA (Full Funding Grant Agreement). The general objective is to develop a project management plan, framed within the standards established by the Project Management Institute (PMI), to improve the chances of success of the Dulles Corridor Metrorail Construction Project. The management approach described in the PMP is also designed to ensure that the project is completed in accordance with WMATA standards so that the project can be successfully accepted into the WMATA metrorail system. The specific objectives are to develop a scope management plan to define key stakeholders’ project requirements and expectations; to create a schedule management plan for assigning duration to work packages, to be monitored and controlled accordingly; to create a cost management plan for assigning cost to work packages, to be monitored and controlled accordingly; to develop a quality management plan for outlining the stakeholders’ acceptance criteria to be addressed with the project execution; to create a resource management plan for assigning adequate human and physical resources to project work packages; to develop a communication management plan for clearly defining the project communication strategies; to create a risk management plan that identifies and prioritizes risks, provides the corresponding risk response approach for the project, and identifies potential opportunities; to develop a procurement management plan for identifying and assigning the contract types to the corresponding project suppliers, including their limitations, restrictions, or expectations; and to develop a stakeholder management plan that identifies key stakeholders, their level of interest, and their impact/influence on the project to ensure their engagement.

This project management plan recommends to develop and implement a plan, with milestones, to ensure that the Metropolitan Washington Airports Authority carries out appropriate stray current tests to calculate the piles of corrosion rate and estimates their remaining years of service. Develop and implement a plan, with milestones, to ensure that the Metropolitan Washington Airports Authority installs any applicable corrosion protection measures that emerge from the stray current tests before the Washington Metropolitan Area Transit Authority accepts the final Dulles project.

CHAPTER I. INTRODUCTION

1.1. Background

The Metropolitan Washington Airports Authority has realized the need to develop the project management plan (PMP) for phase 1 and phase 2 of building the local alternative (LPA), the Dulles Corridor Metrorail Project. The project will change, manage, and control until and upon conclusion of a full funding agreement (FFGA) with the Federal Transit Administration (FTA) under section 5309 of the New Starts program. The project management plan is done in order to set up, in accordance with the understanding of the FTA guidelines for project and construction management, update 2003 and 49 CFR Part 633.25, content of a project management plan and ensure that the project is completed with the first of the FTA circular C5010.1C, in accordance with the guidelines for grant management and related status and project management control of section 5309 of the New Starts program.

The project management plan will be constructed using the effective projects from those responsible for the Airports Authority who use their experience of using transit and design build maintenance to manage and control the rights of the design build contractor (Dulles Transit) Partner (DTP), the Washington Metropolitan Area Transit Authority (WMATA), and other agencies and interest groups.

The planned Dulles Corridor Metrorail Project is a 23-mile extension of Washington's existing metrorail system. It is being built in two phases by the Metropolitan Washington Airports Authority (MWAA). Phase 1 of the new line will be opened, connecting East Falls Church with Tysons Corner and Reston and Virginia's largest employment centers with downtown Washington and Largo, Maryland. Known as the Silver Line, the extension is operated by the Metropolitan Washington Area Transit Authority (WMATA).

The line will provide a one-seat, no transfer ride from Dulles to downtown Washington, creating the long sought-after connectivity between the burgeoning Dulles corridor and the nation's capital. The railway construction extension will include the 11 new stations.

The development and impairment of an effective PMP is essential for the success of a large capital project, that of highly complex companies like the project. The PMP will be effective projects from those responsible for the Airports Authority Project who use their experience of using transit and design build maintenance to manage and control the rights of the design build contractor (Dulles transit) partner (DTP), the Washington Metropolitan Area Transit Authority (WMATA), and other agencies and interest groups.

The project management plan will be a dynamic document. The project management plan for this project will be the main processing phase of project development. While the final design and construction will overlap for a period during this design-build project, this version of the project management plan will focus mainly on the construction stage of the project. It defines management responsibilities; project staff roles; and interactions between project staff, consultants, and other agencies and organizations. It also specifies the general procedures and management tools that will be used to ensure an effective project control and successful project completion.

1.2. Statement of the Problem

For the construction of the Dulles Metrorail Project, the problems with scheduling, time-bound restrictions, track of records, and progress traction were identified to be unmanageable; hence, when a large-scale research effort was done, which assisted in discovering and analyzing some of the largest transportation issues, it was confirmed that the current construction project is not sufficient. The current project plan does not cover the details necessary to successfully complete the understanding of the multi-phase construction involved at high level magnitude in order to build a mitigation solution, hence the need for an efficient project management plan.

Due to the size and complexity of the project, it is of great importance to provide an extensive management tool. Each section of the project management plan will be created, along with all of the tools, techniques, and concepts used to verify and validate each management decision selected for application to focus on

four areas: safety, renewal, reliability, and capacity for the construction project. This project management plan is created to coordinate the numerous planning activities necessary to ensure a successful project completion.

1.3. Purpose

The purpose of developing a project management plan is to integrate sustainable principles in order to effectively carry out project management activities so that the Dulles metrorail construction can be completed within the planned functional scheduled timeframe, with the desirable quality, and within budget. Just like every other project area, construction projects may fail for several reasons. There is no single method or organizational structure that can be used to manage projects to success. Project failure can happen in any organization and to any project. There is an infinite number of reasons for failure. Sometimes, failure is controllable. To overcome failure for this massive project, a “project management plan” will be created.

The goal of project management is to produce a successful construction and not be hindered by the errors of omission as well as commission by management, project managers, team members, and others associated with the projects. The purpose of this project management plan is to enable the identification of the common causes of project failures through the use of surveys to collect information, which can be used to mitigate occurrences and in many cases, repair the damage that was caused and recover the project.

The project management plan is created in order:

1. To create a project management plan that integrates sustainable principles to effectively carry out project management activities
2. To provide planning for an outcome of high-quality and high-capacity transit service in the Dulles Corridor
3. To improve public involvement notices and support the collaboration for local people, business owners, and press meetings

4. To improve internal communication, coordination, and streamline decision-making. To tntegrate [resources] across all project delivery phases.

1.4. General Objective

To develop a project management plan, as per the standards of the Project Management Institute (PMI), that integrates sustainable principles to optimize the utilization of project resources during the construction of the metrorail extension to the Dulles International Airport and Loudoun County.

1.5. Specific Objectives

The specific objectives of the project management plan are done in order:

1. To create a project charter to formally authorize the project and provide the project manager with the authority to apply organizational resources to the project and to produce the project management plan
2. To create a project scope management plan to formally authorize the project and provide the project manager with the authority to apply organizational resources to the project and to produce the project management plan
3. To create a balanced schedule management plan to assign duration to work packages that can be tracked
4. To create a balanced cost management plan to allocate costs to work packages
5. To create a sustainable quality management plan to define the minimum stakeholder acceptance criterion
6. To create a sustainable communication management plan to clearly define the communication strategy of the project and reporting authorities
7. To create a sustainable risk management plan that identifies risks and risk responses that are directly related to the project and affect sustainability

8. To create a sustainable order/procurement management plan to identify and assign contracts to suppliers who can obtain sustainable goods and services
9. To create a stakeholder management plan that identifies key stakeholders and their interests and analyzes how their impact can affect the project

CHAPTER II. THEORETICAL FRAMEWORK

2.1. Company/Enterprise Framework

2.1.1. Organization Background

Dulles Transit Partners LLC (DTP) selected Bechtel Infrastructure Inc. and Washington Group International (now URS) to construct phase 1 and phase 3 of the 11.6-mile Project. DTP is a joint venture. Bechtel has been selected by the Metropolitan Washington Airports Authority (MWAA) to submit a proposal to design and build phase 2 of the Dulles Corridor Metrorail Project. Phase 2 will provide rail service between Washington, D.C., and Washington Dulles International Airport, which is not included in this project.

The company will build the first phase of the new rail line and is one of five teams to make MWAA's short list of phase 1 bidders. The project is really about the cooperative efforts of several third parties. Because of the initial support and continuing efforts of the Federal Transit Administration, the Virginia Department of Transportation, the Washington Metropolitan Area Transit Authority (metro), Virginia's Department of General Services, and others, the project would not be where it is today. This project will do more than extend a rail line, expecting it to change the local landscape.

The Dulles metrorail extension will be built by a Bechtel-led team. The Metrorail Silver Line runs 11.5 miles (18.5 kilometers) through an extremely congested corridor, bringing rail service to the fast-growing areas of Northern Virginia and providing a direct ride from Dulles International Airport to downtown Washington, D.C. Washington Group International (URS) Corporation provided professional planning and design, systems engineering and technical assistance, program and construction management, and operation and maintenance services for transportation, commercial/industrial, facilities, environmental, water/wastewater, homeland security, installations and logistics, and defense systems. The company provided engineering and technical services to federal, state, and local

governmental agencies as well as private clients in the chemical, pharmaceutical, oil and gas, power, manufacturing, mining, and forest product industries.

2.1.2. Mission Statements

> The Secretary of Transportation Shirley Ybarra formed the Dulles Corridor Task Force. At its first meeting in August 1998, the task force adopted a mission statement “determine the most suitable means to implement an innovative bus system in the Dulles Corridor and determine the steps necessary to complete the Preliminary Engineering (PE) study for the rail system”. (Dulles Corridor Metrorail Project, n.d.b, section: July 1998, para. 1)

For the Dulles Corridor Metrorail Project (n.d.a) The Virginia Department of Rail and Public Transportation (DRPT) issued the mission statement - Dulles Metrorail Project “to plan, establish, maintain, improve and promote public transportation services, rail passenger and freight rail transportation systems, and transportation demand management strategies that provide efficient mobility and transportation choices to the citizens of the Commonwealth”.

The initiatives used to implement its mission were the following:

1. Supporting systematic decision-making
2. Providing an expeditious method for moving low-risk project components forward
3. Assessing potential environmental impacts according to their degree of impact severity
4. The Feasibility Plan, which outlines the program needs, component projects, and partners’ goals and responsibilities
5. Projects that identify each project’s intent, description, and limits and the screening process for each project, including a test of NEPA principles
6. Logical termini—The project has rational end points for transportation improvements and rational end points for environmental impact review.
7. Independent utility—The project is usable and a reasonable expenditure if no additional transportation improvements in the area are made.

8. Restriction of alternatives—The project does not constrain other potential transportation improvements in the project area.

2.1.3. Vision Statements

The vision statement of Bechtel Infrastructure Inc. is to “be the world’s premier engineering, construction, and project management organization by achieving extraordinary results for customers, building satisfying careers for people, and earning a fair return on the value we deliver” (Bechtel Corporation, n.d.b, para. 1).

2.1.4. Organizational Structure

This section discusses the overall approach for managing the design and implementation of the project by understanding the organization structure. Considering this is a large-scale project, we will be discussing the project organization structure, since the metrorail construction is not possible without numerous partnership collaboration efforts. This also outlines how the participating agencies and entities are organized and staffed. As the implementation of the project proceeds from final design through construction and start-up, the organization will evolve to maximize the efficient use of personnel and will adjust to the changing workload (Dulles Corridor Metrorail Project, n.d.a)

Airports Authority will see the need to keep the project management plan updated prior to each stage to reflect changes in the organization and management policies and procedures. The management structure draws on the strengths and capabilities of each organization to implement the project in a timely and cost-effective manner. This section summarizes the roles of the principal participants involved in final design and construction (see figure 1).

There are four main departments:

1. High Level Project Organization Hierarchy
2. Airport Agency Organization:
3. Transit Partners- Engineering organization
4. Construction Dept. Organization

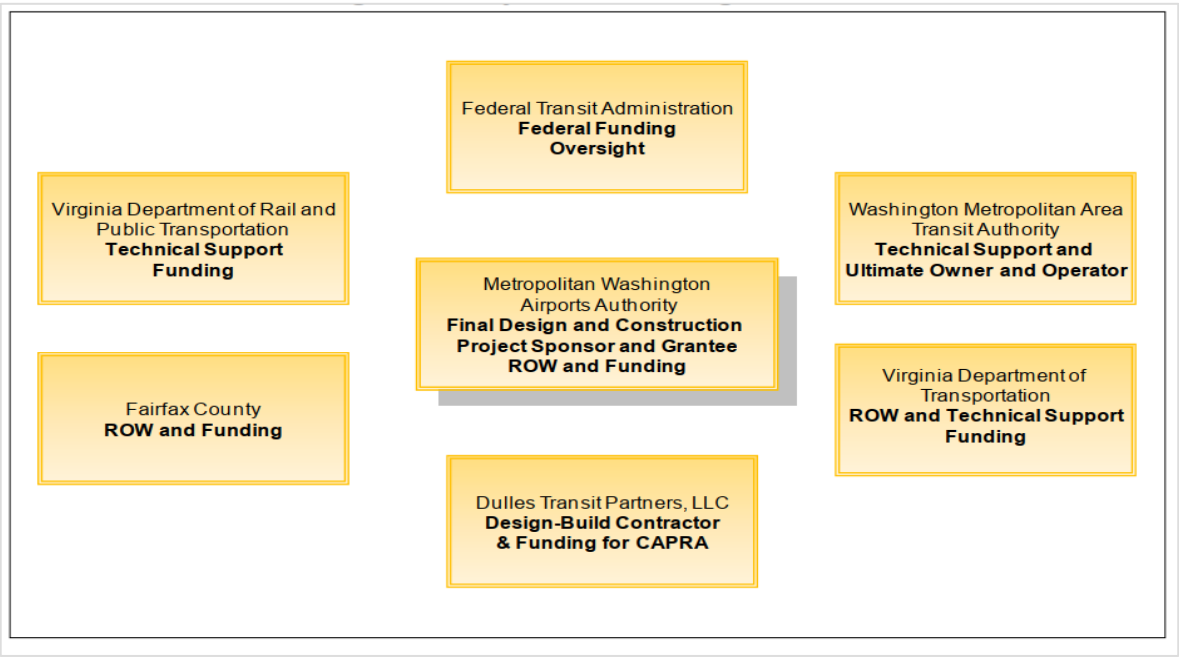


Figure 1. *Functional Organization Structure.*
Source: Compiled from Dulles Corridor Metrorail Project (n.d.a) website.

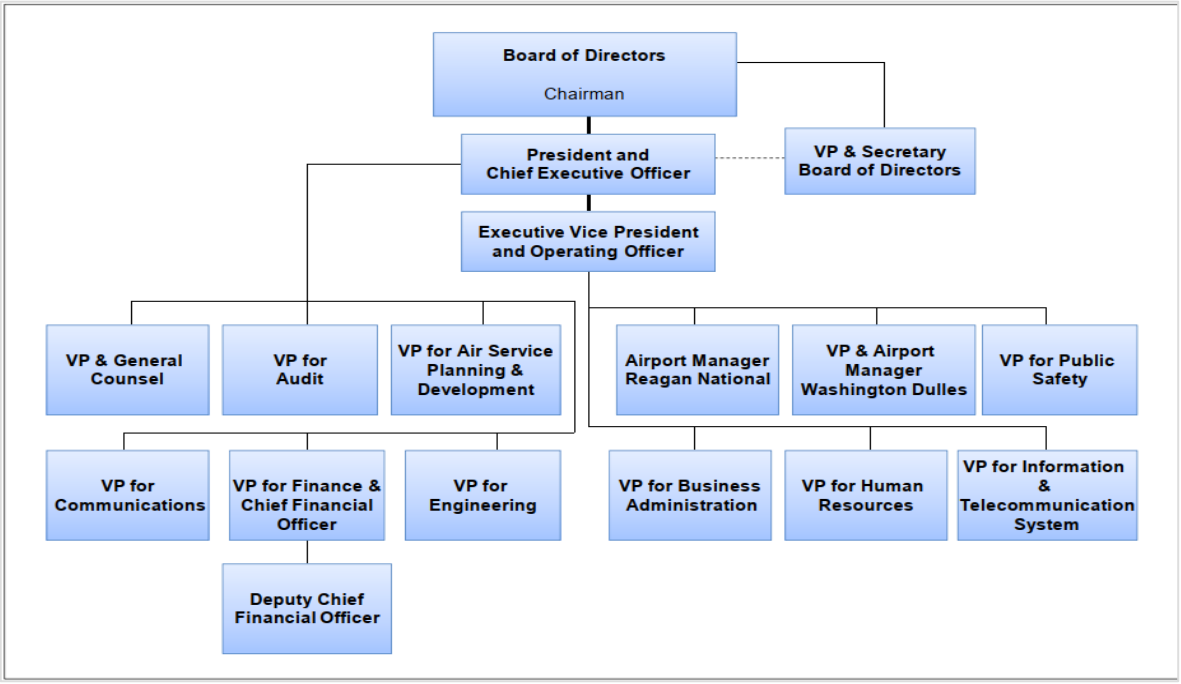


Figure 2. *Project Organization Hierarchy*
Source: Compiled from Dulles Corridor Metrorail Project (n.d.a) website.

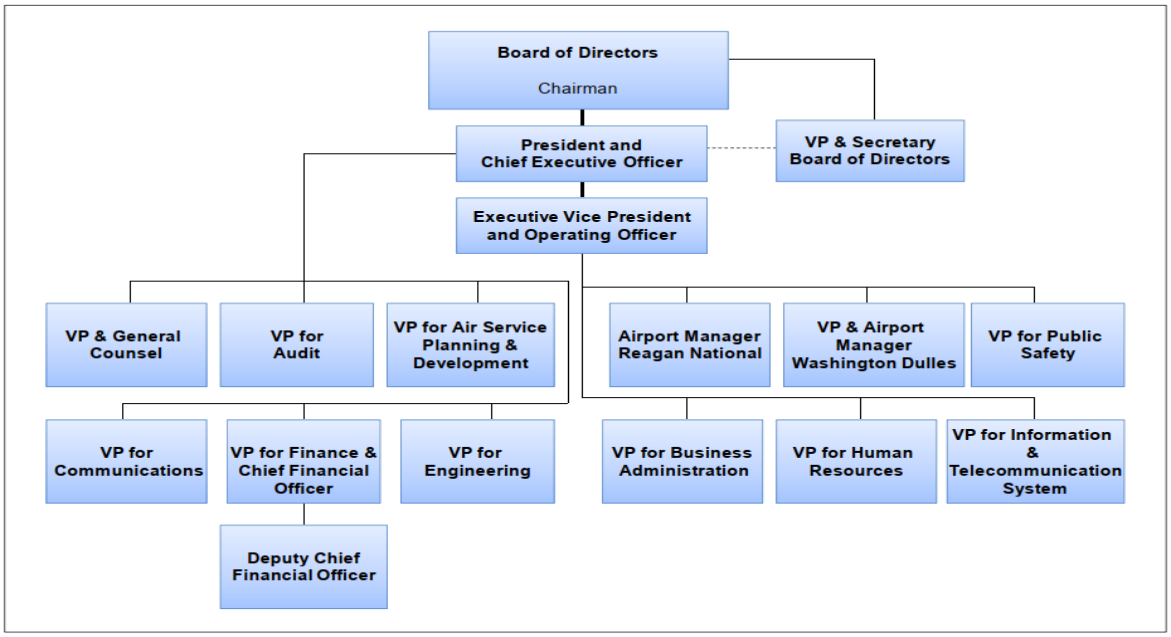


Figure 3. *Project Airport Agency Hierarchy.*
Source: Compiled from Dulles Corridor Metrorail Project (n.d.a) website

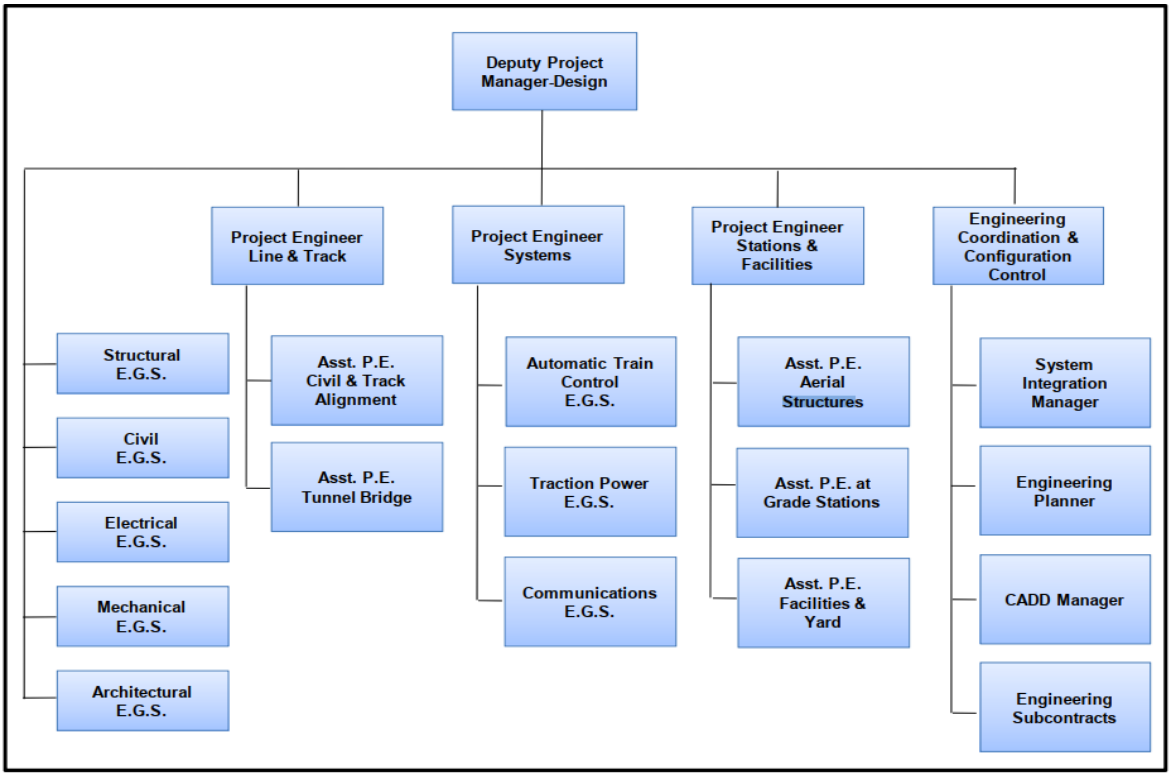


Figure 4. *Project Transit Partners Engineering Hierarchy.*
Source: Compiled from Dulles Corridor Metrorail Project (n.d.a) website.

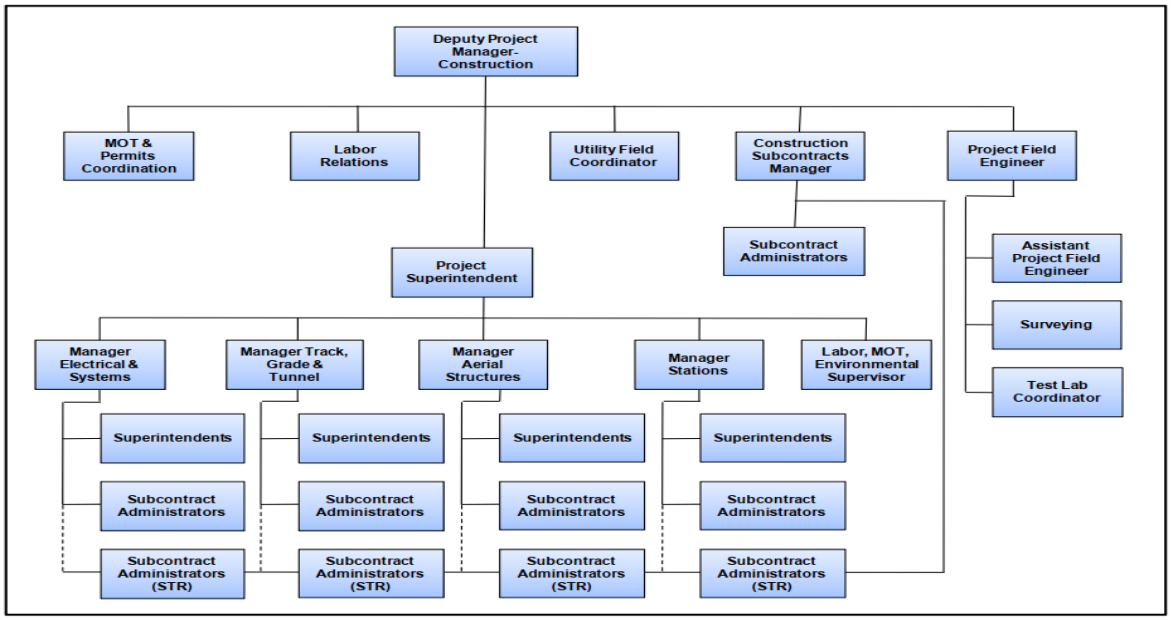


Figure 5. *Project Construction Department Hierarchy.*
Source: Compiled from Dulles Corridor Metrorail Project (n.d.a) website.

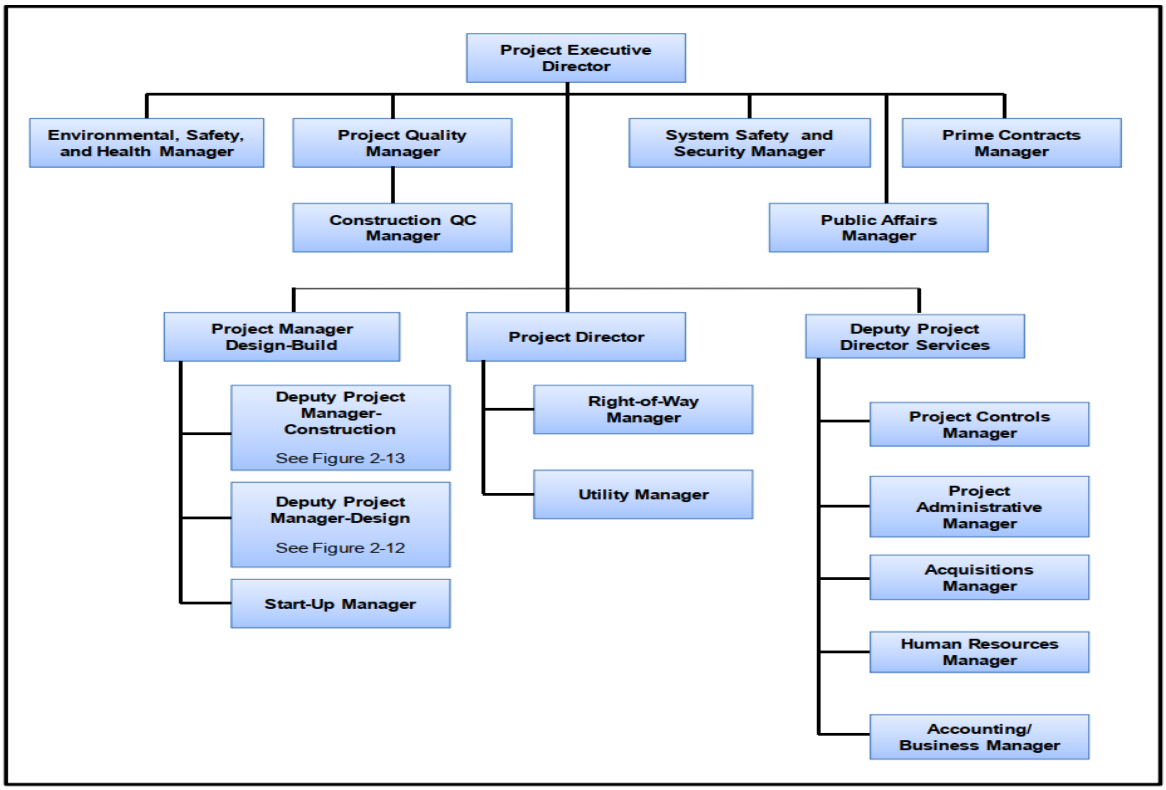


Figure 6. *Project Construction Department Hierarchy*
Source: Compiled from Dulles Corridor Metrorail Project (n.d.a) website.

2.1.5. Products Offered

Bechtel is one of the oldest and largest family-owned and operated corporations in the United States, Launched originally as a railroad-grading operation in the Oklahoma territory, the company says it has since grown into a multinational company with hundreds of projects around the world. Four generations of the Bechtel family have guided the company through 23,000 projects in 140 countries on seven continents. These include high-profile, complex projects like the Hoover Dam, the Channel Tunnel, and the San Francisco Bay Area Rapid Transit system, according to Bechtel (Bechtel Corporation, n.d.a).

The company's portfolio includes energy, transportation, communications, mining, oil and gas, and government services. Bechtel boasts record revenues over the last five years, and Engineering News-Record has named the company the top U.S. construction contractor for 11 straight years, the company says. Currently, they have projects in dozens of locations worldwide, from Alaska to Australia. No matter how challenging a project or how remote its location is, chances are that Bechtel can handle it. That is because we bring an unmatched combination of knowledge, skill, experience, and customer commitment to every job.

Bechtel's capabilities include:

- Airports and seaports
- Communications networks
- Defense and aerospace facilities
- Environmental cleanup projects
- Fossil and nuclear power plants
- Mines and smelters
- Oil and gas field development
- Pipelines
- Roads and rail systems
- Refineries and petrochemical facilities

Bechtel has headquarters in San Francisco and offices throughout the world. Washington Group International was an American corporation that provided

integrated engineering, construction, and management services to businesses and governments around the world. The company is the biggest engineering, design, and construction firm and a U.S. federal government contractor. Headquartered in San Francisco, California, URS was a full-service, global organization with offices located in the Americas, Europe, Africa, and Asia-Pacific. URS and Bechtel provide the following services: design-build, general construction, architecture and engineering services, project management, 3D illustrations and presentations, land development services, furniture and interior designs, project feasibility studies and analyses, architectural surveying, and as-built drawings.

2.2. Project Management Concepts

2.2.1. Project

The sixth edition of the PMBOK® Guide by the Project Management Institute (PMI, 2017) details the framework in which project management exists, starting with section 1.2: Foundation Elements (section 1.1 describes the purpose of the guide). This section starts with the definition of a project:

“A project is a temporary endeavor undertaken to create a unique product, service, or result” (PMI , 2017, p. 4).

Projects are different from other ongoing operations in an organization because unlike operations, projects have a definite beginning and end; they have a limited duration. Projects are critical for performing an organization's business strategy because projects are a means by which the strategy of the company is implemented. Projects also involve one or more elements that have not been done in the past and are therefore unique. A product or service may be unique even if the category to which it belongs to is large as defined by PMI (2017).

According to Simpkin (1976):

Construction management is the integration of the various components of the architectural, engineering, and construction cycle into one continuous, free-flowing, well-managed, and harmonious progression. The construction manager does not perform any design or construction contracting and must, therefore, be assumed to

maintain a cold objectivity in the management and coordination function. The prerequisites of construction management are good knowledge of the architectural, engineering, and construction fields plus a superior background in planning, scheduling, and directing of the many activities of a multi-disciplined team. The emphasis is placed on management with a strong capability in the use of advanced time and cost control systems. (section: CM — the Alternative, para. 1)

Although the construction management (CM) concept is widely used today, it is not so widely accepted, as it might be expected. The General Service Administration (GSA) is said to have “spearheaded national interest in CM.” Management of construction projects. (n.d.). Retrieved July 13, 2020, from pmi org learning management construction-projects-manager-contracts-1750. The U.S. Department of Health Education and Welfare (HEW) has given a specific definition to the CM, as it is to be used in HEW projects. Recently, the GSA led to a pamphlet being published, instructing and encouraging local governments to utilize the services of construction managers. (Simpkin, 1976, para. 5)

Construction projects are the organized effort to construct a building or structure. In the fields of civil engineering and architecture, construction projects involve the process that consists of tangibly assembling an infrastructure or building.

The project vision for Bechtel construction is the following:

1. To achieve safer and better projects faster and more cost-effectively, you can work with industry stakeholders while meeting society's sustainability expectations.
2. Ethics: we are uncompromising in our integrity, honesty, and fairness.
3. As a tangible value, a 20% reduction in investment costs in capital and infrastructure as well as over the duration of the project, and to avoid injury and emission standards The industry will also adopt some soft values: performance as a leader in sustainable development (SD); hiring well-trained, ethical, competent, and technology-conscious employees; the use

of advanced delivery methods and project resources; and actual modeling of project management values, and serve as an educational industry that continually provides value to the industry and society.

4. Quality: we are passionate about excellence and doing our work right the first time. Our reputation depends on our delivered value in the eyes of every customer and community.
5. People: we inspire each other with important work full of purpose, challenging development opportunities, and rewarding careers. We aspire to be the employer of choice in our industry.
6. Culture: we actively build a diverse, inclusive, and collaborative work environment where all views are welcomed, openness is encouraged, and teamwork and merit are cornerstones. We are proud of what we do and how we do it—and we enjoy doing it!
7. Relationships: we build positive, long-term relationships with our customers, joint-venture partners, subcontractors, suppliers, and colleagues that are built on trust, respect, and collaboration.
8. Innovation: we develop and apply world-class technology. We listen, learn, and seek out the best ideas. We attack complacency and continually improve.
9. Sustainability: we improve the quality of life in communities where we work by respecting local cultures, engaging local people, and protecting the environment.

2.2.2. Project Management

The project is temporary because it has a defined beginning and an end in time and therefore, a defined scope and resources. The design is unique because it is not a routine operation but a specific set of operations designed to achieve a single goal. The project team is usually made up of people who generally do not work together, sometimes from different organizations and countries. Software development to improve the business process, construction of a building or bridge, assistance after a natural disaster, expansion of sales in a new geographic market -

all projects. Everything must be managed competently to ensure timely and budgetary results and the learning and integration that organizations need.

Therefore, project management involves applying knowledge, skills, tools, and techniques to the project activities to meet the project requirements. It was always practiced informally, but it began to appear as a separate profession in the mid-20th century. The PMI Guide to Project Management (PMI, 2017) identifies the recurring elements:

Project management processes fall into five groups:

1. Initiating
2. Planning
3. Executing
4. Monitoring and controlling
5. Closing

Project management knowledge draws on ten areas:

1. Integration
2. Scope
3. Time
4. Cost
5. Quality
6. Procurement
7. Human resources
8. Communication
9. Risk management
10. Stakeholder management

A key factor that differentiates between project management and "management only" is that, unlike ongoing process management, it has this final and limited time frame. For this reason, a project professional needs a wide range of

skills, often technical skills, certainly human resource management skills, and good business awareness.

2.2.3. Project Life Cycle

According to the PMBOK® guideline (PMI, 2017), the project life cycle refers to the four-step process: initiation, planning, execution, monitoring and control, and closing. These five groups represent the processes that a typical project will go through.

The project life cycle provides a framework for managing any type of project within a business. Leaders in project management have conducted research to determine the best process by which to run projects. It has been found that following a project life cycle is critical for any service organization. The project life cycle is the standard process by which teams achieve project success. According to the Project Management Institute, the project life cycle is critical for any manager hoping to deliver projects to clients successfully.

The project phases involved are the following:

- **Phase 1:** The initiation or conceptualization phase
- **Phase 2:** The planning phase
- **Phase 3:** The execution phase
- **Phase 4:** The termination phase

Phase 1: The Initiation or Conceptualization Phase

“A strategic need for the project or service must be recognized by upper management” (Mavenlink, n.d., section: Phase #1, para. 1). The conceptualization phase typically involves the following elements:

- The creation of the statement of work (SOW)
- Presenting the business case
- The creation of a business contract

Phase 2: The Planning Phase

"The second phase of the project management life cycle is referred to as the planning phase" (Mavenlink, n.d., section: Phase #2, para. 1). The planning phase typically involves the following elements:

- Determining resource availability
- Creating a project budget
- Beginning to allocate tasks to certain resources

Phase 3: The Execution Phase

According to Mavenlink (n.d.):

The third phase is labeled execution. This is when the actual work of the project is performed. Required materials, tools, and resources are transformed to reach the project goals. During this phase, performance is continually measured to ensure the project is successful. (Mavenlink, n.d., section: Phase #3, para. 1).

The execution phase typically involves the following elements:

- Strategic planning
- Implementation planning

Phase 4: The Termination Phase

"The fourth and final phase is called termination phase, also referred to as project closure. This phase begins once the project has been completed" (Mavenlink, n.d., section: Phase #4, para. 1). The termination phase typically involves the following elements:

- The disbandment of the project team
- Personnel and tools are reassigned to new duties.
- Resources are released back to the parent organization
- The project is transferred to the intended users.

Mavenlink (n.d.) stated that:

The key difference between the standard project life cycle and the professional services project life cycle is that the standard life cycle lacks fluidity and feedback between projects. The professional services life cycle vs. the standard project life cycle. The standard project life cycle has endured throughout the years despite the growing complexities surrounding project management. (section: What is the Professional Services Project Life Cycle?, para. 1)

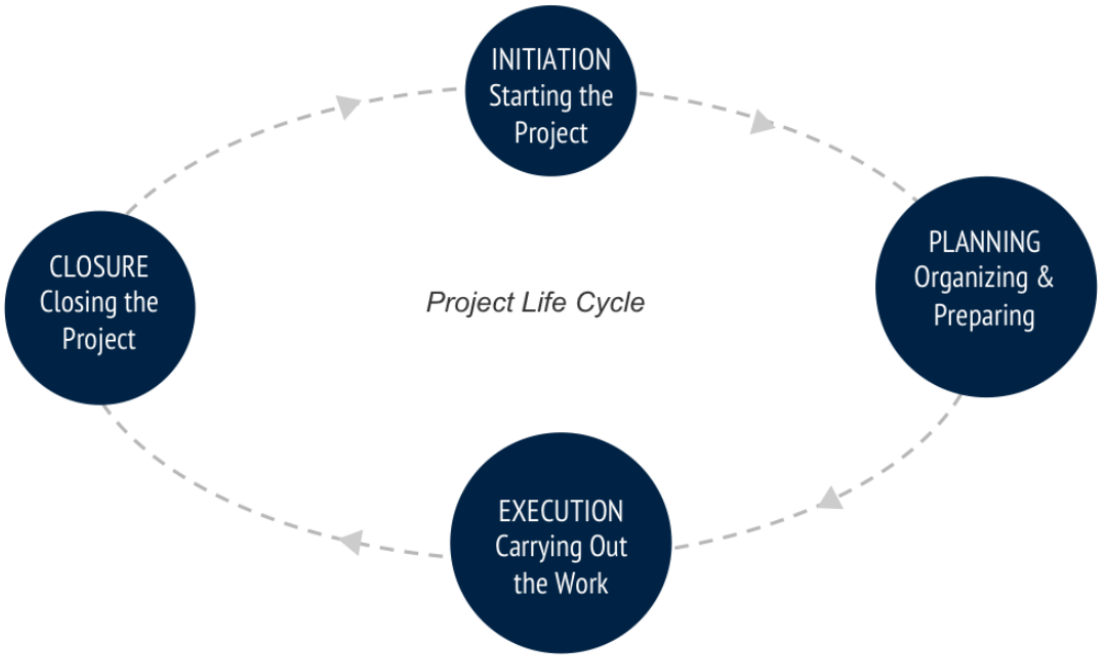


Figure 7. *Project Life Cycle and Main Characteristics Project Life Cycle and Main Characteristics*
Source: Mavenlink (n.d.).

Project management process groups are linked by the objectives they produce. The output of one process generally becomes an input to another process or is a deliverable of the project. The planning process group provides the executing process group with a documented project management plan and project scope statement and often updates the project management plan as the project progresses. In addition, the process groups are seldom either discrete or one-time events; they

are overlapping activities that occur at varying levels of intensity throughout the project.

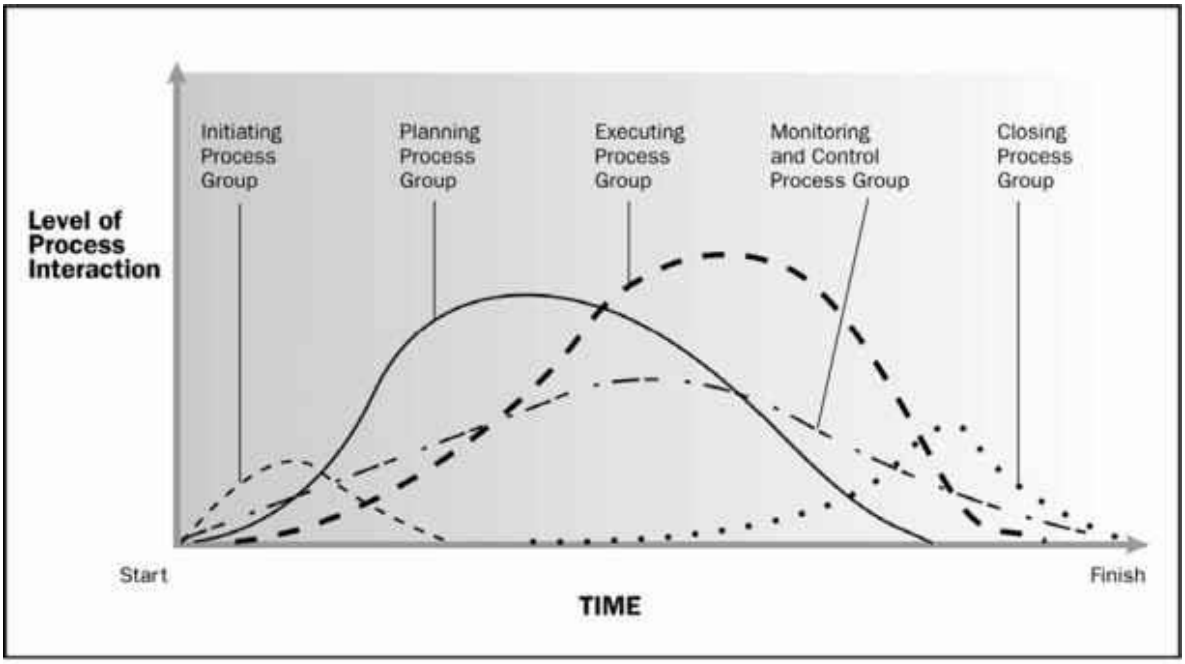


Figure 8. *Process Groups Interacting in a Project.*
Source: Grist Project Management (2019).

2.2.4. Project Management Process

The five phases of a project are the following (see figure 9):

1. Initiation

This is where all projects begin. The value of the project is determined, as well as its feasibility. Before the project is approved or rejected, these two documents are created to sell the work to stakeholders or sponsors:

- Business case: Here is where you justify the need for the project, which includes analyzing the return on investment.
- Feasibility study: You need to evaluate what the project's goals are, the timeline to completion, and how much the whole endeavor will cost. You also note what resources will be required to fulfill the project and if it makes financial and business sense.

2. Planning

If the project is approved, then the next step is to assemble a project team and start planning how to manage the project so it can achieve its goals within budget and on time. The project plan will include what resources are needed, financing, and materials. The plan also gives your team direction and the following elements:

- Scope: There will be a written scope statement that reiterates the need for the project and what its deliverables and objectives are.
- Definition: Here, you break down the larger deliverables into smaller ones, which will help with managing them.
- Tasks: This is where you identify what tasks are necessary to produce the deliverables and figure out if any tasks are dependent on other tasks.
- Schedule: This is where you determine the duration of the tasks and set dates for their completion.
- Cost: This is where you estimate the costs involved across the project and formulate a budget.
- Quality: This is where you make sure the quality objectives are met throughout the project.
- Organization: This is where you note how the project will be organized, including reporting on progress.
- Staff: This is where you determine the roles and responsibilities of the project team.
- Communication: This is where you decide how information will be disseminated, to whom, and with what frequency.
- Risk: This is where you determine what risks are likely, how they'll impact the project, and then plan how to resolve them.
- Procurement: This is where you decide what work or materials will be contracted, define those contracts, and who they'll go to.

3. Execution

Now that you have done your planning, it is time to start the project. This is where the rubber hits the road, but that does not mean you are just cruising. This phase is made up of these detailed processes:

- Executing the plan: Follow the plan you created, assign the tasks to team members, and manage and monitor their progress with project management tools, like a project dashboard.
- Administrating: Manage the contracts secured in the project.

4. Monitoring and Controlling

To ensure that the project plan is being updated, all aspects of the project must be monitored and adjusted as needed. To do this, follow these processes:

- Reporting: Have a metric to measure project progress and an instrument to deliver this information.
- Scope: Monitor scope and control changes.
- Quality: Measure the quality of deliverables and make sure that the planned quality is being met; if it is not, evaluate how to improve the quality.
- Schedule: Keep track of delays or blocks that impact the timeline of the project and adjust it to stay on track.
- Cost: Monitor expenses and control cost changes.
- Risk: Note changes in risk throughout the project and respond accordingly.

5. Close

The project is not over once the project goals and objectives have been met.

The last phase of the project is closing it. This involves another set of processes:

- Scope: Make sure the project deliverables have been completed as planned.
- Administration: Close all outstanding contracts and administrative matters, archive the paperwork, and disseminate it to the proper parties.

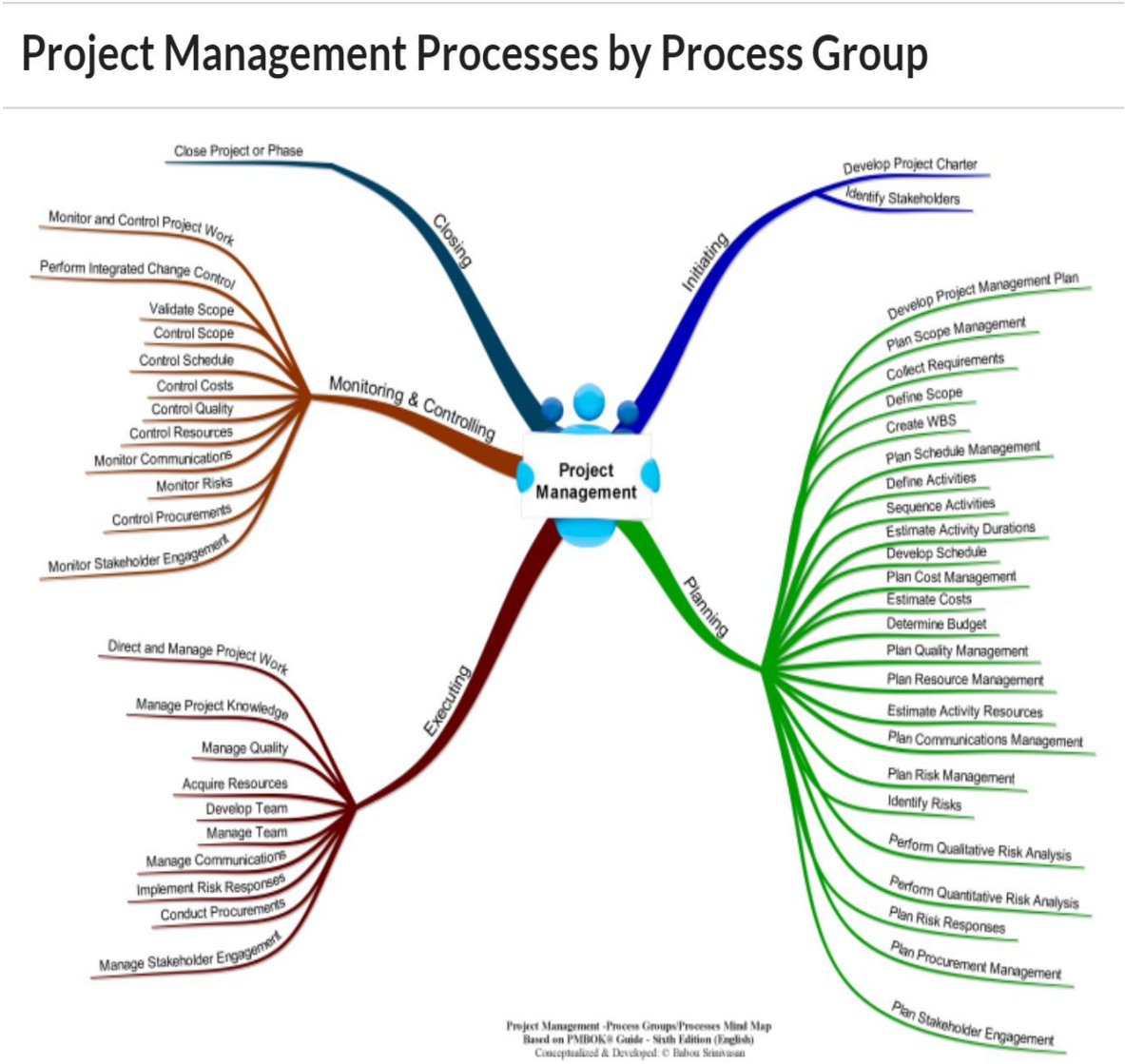


Figure 9. *Project Management Process by Process Group.*
Source: PMBOK® Guide (PMI, 2017).

2.2.5. Project Management Knowledge Areas

The project management knowledge areas, according to PMBOK 6th Edition (PMI, 2017), are fields or areas of specialization that are commonly employed when managing projects. A knowledge area is a set of processes associated with a topic in project management. These 10 knowledge areas are used in the majority of projects most of the time. The needs of a specific project may require additional knowledge areas. The 10 knowledge areas are the following:

1. Project integration management: Project integration management includes the processes and activities to identify, define, combine, unify, and coordinate the various processes and project management activities within the project management process groups.

2. Project scope management: Project scope management includes the processes required to ensure that the project includes all the work required, and only the work required, to complete the project successfully.

3. Project schedule management: Project schedule management includes the processes required to manage the timely completion of the project.

4. Project cost management: Project cost management includes the processes involved in planning, estimating budgeting, financing, funding, managing, and controlling costs so the project can be completed within the approved budget.

5. Project quality management: Project quality management includes the processes for incorporating the organization's quality policy regarding planning, managing, and controlling project and product quality requirements in order to meet stakeholders' expectations.

6. Project resource management: Project resource management includes the processes to identify, acquire, and manage the resources needed for the successful completion of the project.

7. Project communication management: Project communication management includes the processes required to ensure timely and appropriate planning, collection, creation, distribution, storage, retrieval, management, control, monitoring, and ultimate disposition of project information.

8. Project risk management: Project risk management includes the processes of conducting risk management planning, identification, analysis, response planning, response implementation, and monitoring on a project.

9. Project procurement management: Project procurement management includes the processes necessary to purchase or acquire products, services, or results needed from outside the project team.

10. Project stakeholder management: Project stakeholder management includes the processes required to identify the people, groups, or organizations that could impact or be impacted by the project; to analyze stakeholder expectations and their impact on the project; and to develop appropriate management strategies for effectively engaging stakeholders in the project decisions and execution. (PMI, 2017, p. 24)

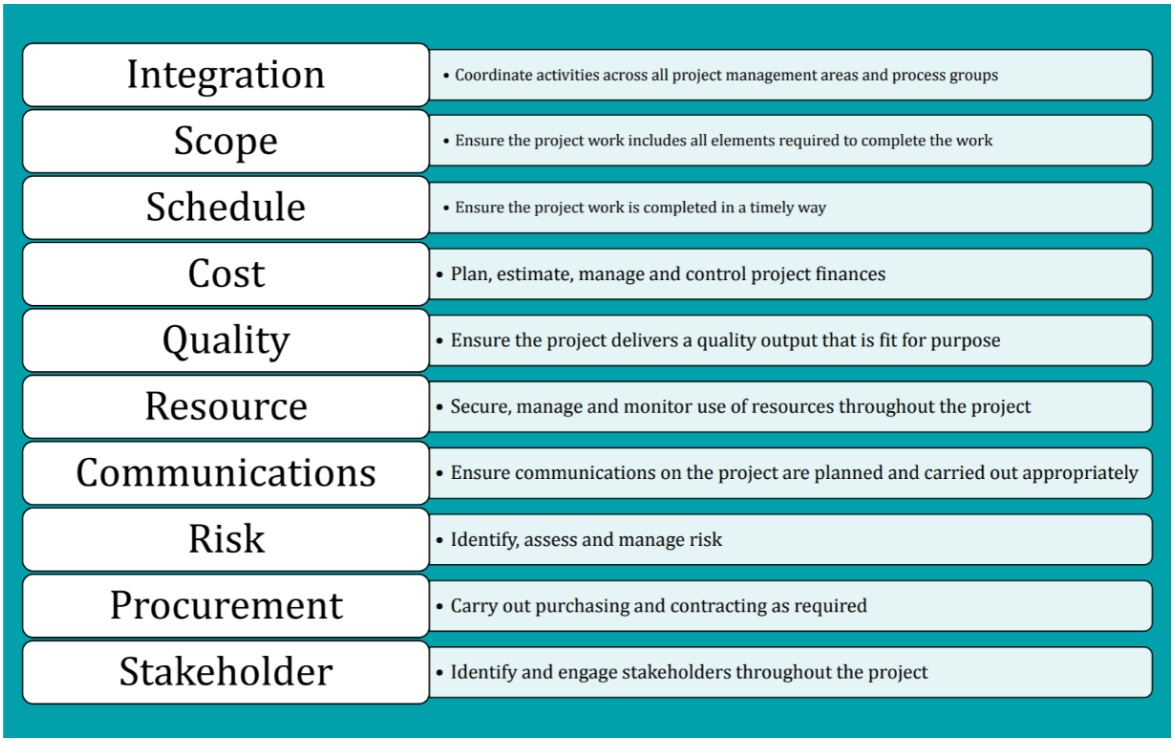


Figure 10. *Project Management Knowledge Areas as per the PMBOK 6th Edition*
Source: Harrin (2020).

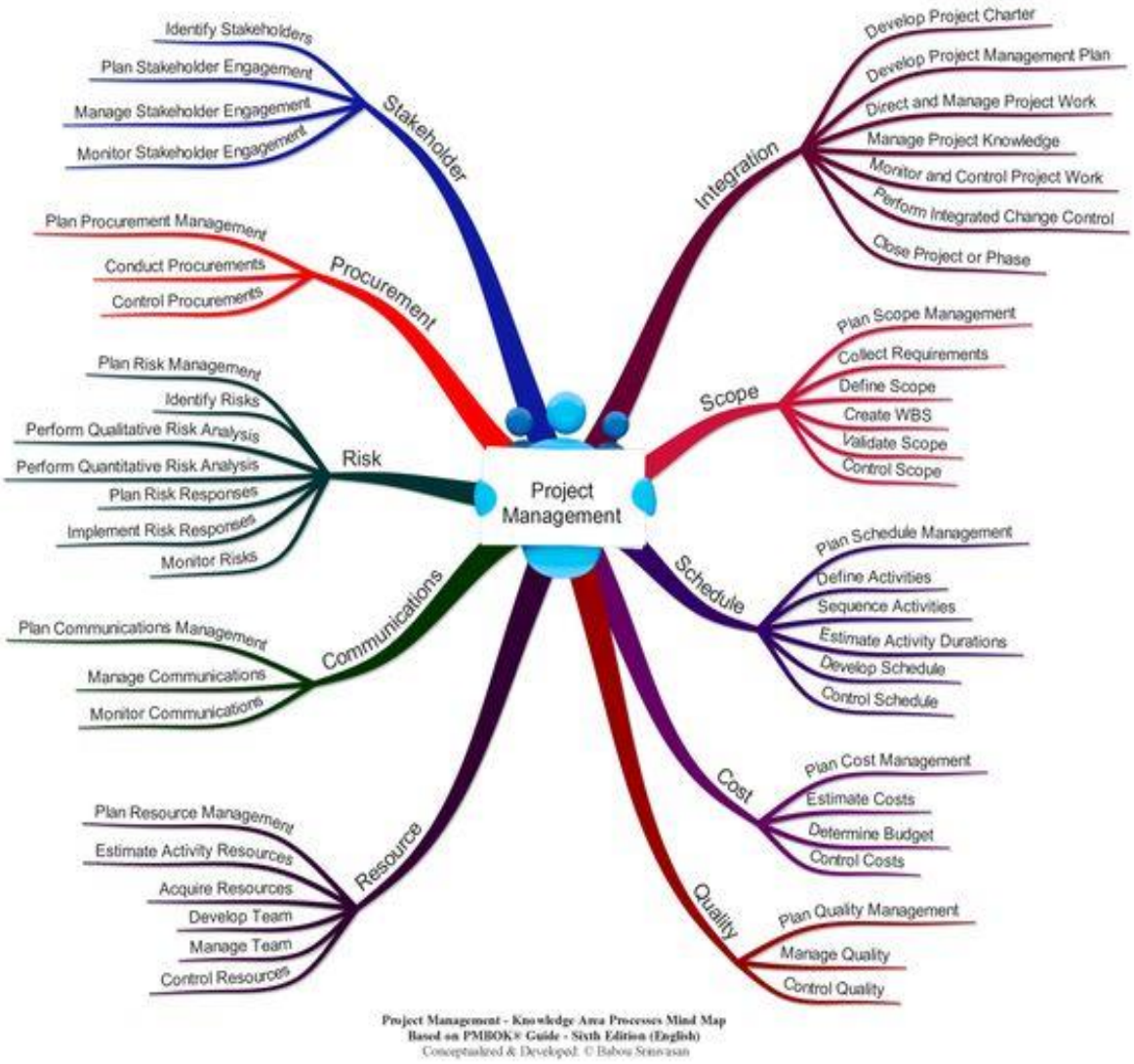


Figure 11. *Project Management Knowledge Areas as per the PMBOK 6th Edition. Source: PMBOK® Guide (PMI, 2017).*

This construction extension provides construction-specific guidance for the project management practitioner for each of the PMBOK® Guide knowledge areas as well as guidance in these additional areas that are not found in the PMBOK® Guide (PMI, 2017):

- All project resources, rather than just human resources
- Project health, safety, security, and environmental management
- Project financial management, in addition to cost

- Management of claims in construction

The construction extension also follows a new structure, discussing the principles in each of the knowledge areas rather than the individual processes. This approach broadens the applicability of the construction extension by increasing the focus on the «what» and «why» of construction project management. Construction project management is an exclusive subset of project management because there are many more conditions that offer unique challenges and opportunities. Challenges are risks, and these risks are dynamic and diverse.

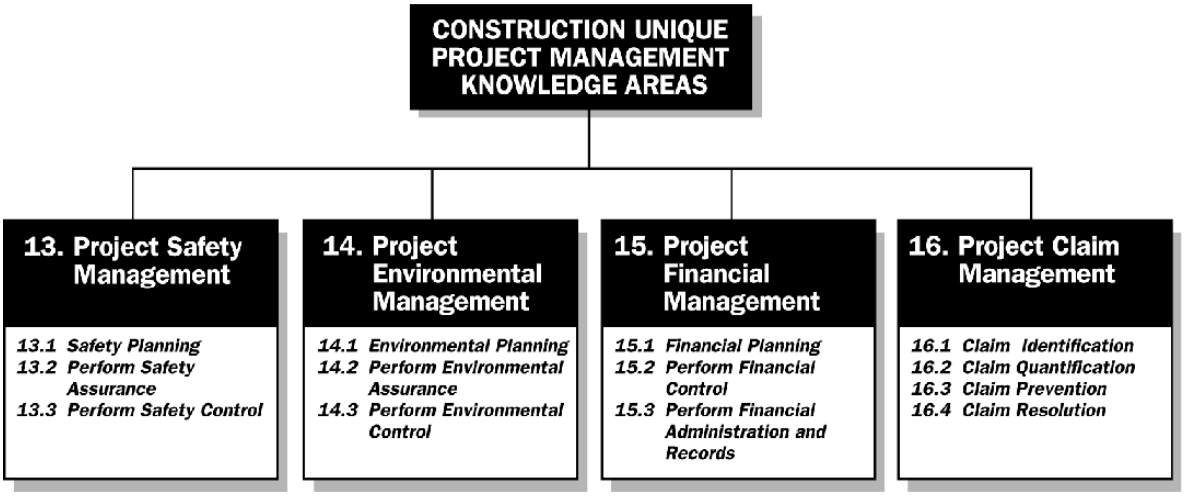


Figure 12. *Construction Management Knowledge Areas.*
Source: PMBOK® Guide (PMI, 2017).

2.2.5.1. Project Integration Management

Project integration management is the coordination of all elements of a project. This includes coordinating tasks, resources, stakeholders, and any other project elements, in addition to managing conflicts between different aspects of a project, making trade-offs between competing requests, and evaluating resources. Assessing the situation and making the decision is a key part of project integration management. Integrated project management helps ensure projects are not managed in isolation. Project integration management is one of the ten key knowledge areas in the PMBOK (Project Management Book of Knowledge). It is considered a critical success factor for project managers and their projects.

2.2.5.1.1. Seven Project Integration Management Processes

Seven processes should be followed for successful project integration management. These processes are the following:

1. Developing the project charter
2. Developing the project management plan
3. Directing and managing project work
4. Managing project knowledge
5. Monitoring and controlling project work
6. Performing integrated change control
7. Closing the project (or project phase)

These integration management processes occur throughout the entire project lifecycle. In other words, at least one of these seven processes fall within each of the five standard phases of a project. This is because managing project integration is an ongoing task that needs to continually happen throughout a project. Because integration management requires the ability to evaluate resources, make trade-offs, and deal with competing activities, project managers need to have a combination of soft skills and hard skills. These include the following:

- Planning
- Organization
- Communication
- Leadership
- Relationship management
- Critical thinking ability
- Data analysis
- Impact assessments
- Scheduling
- Budgeting
- Change management
- Risk management

It is important to build open communication channels with the project team and stakeholders to help ensure information is shared and proper impact assessments are done to identify points of integration or dependencies.

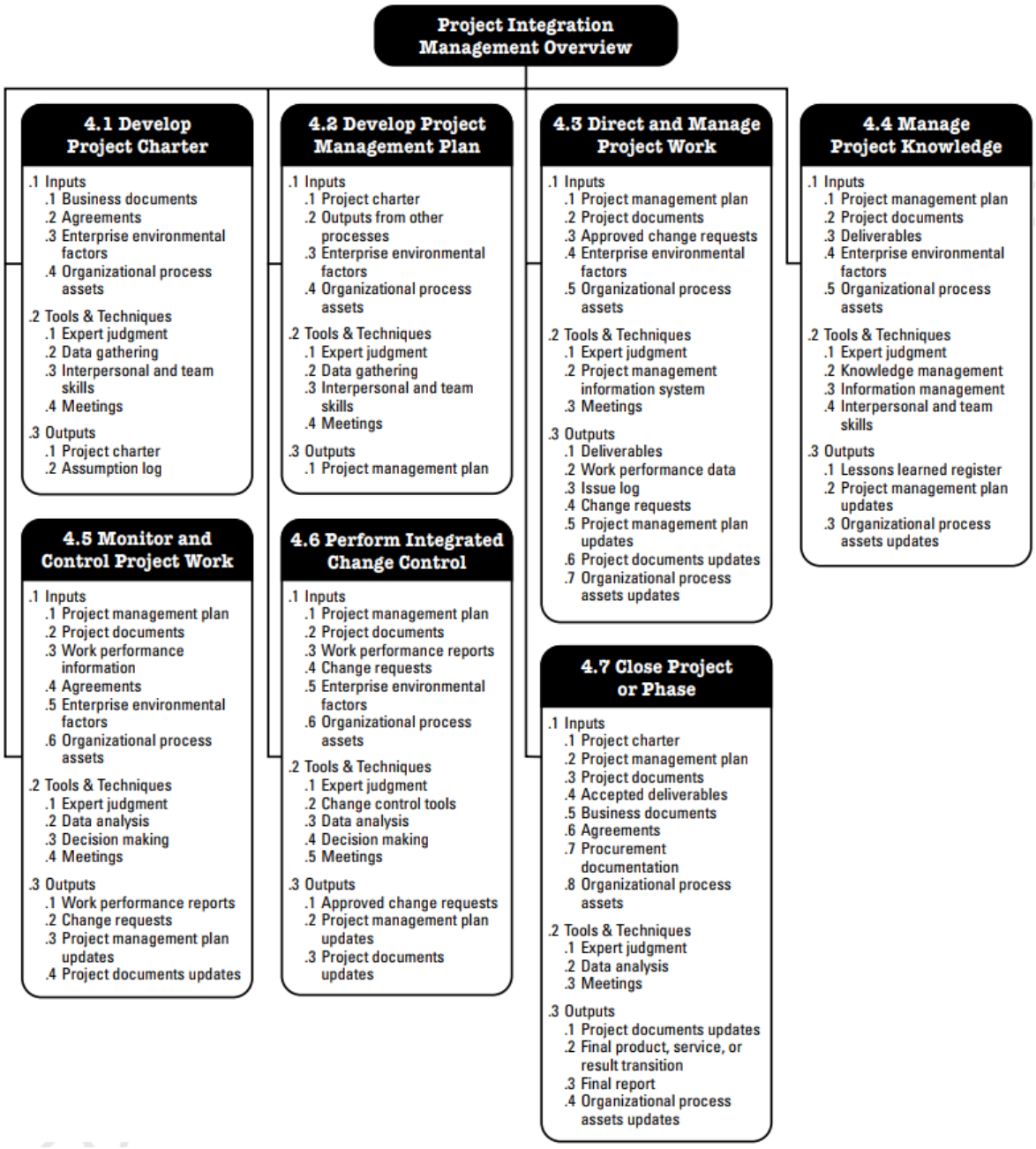


Figure 13. *Project Integration Management.*
Source: PMBOK® Guide (PMI, 2017).

2.2.5.2. Plan Scope Management

Project scope management is the second knowledge area in the Project Management Institute's (PMI) Project Management Body of Knowledge (PMBOK). It includes the processes that ensure all the required work (and only the required work) is included in the project. Newly added into the 6th Edition of the PMBOK (PMI, 2017), this planning step involves the creation of a scope management plan.

According to the PMBOK (PMI, 2017), scope management has six processes:

1. Plan scope management: planning the process and creating a scope management plan
2. Collect requirements: defining and documenting stakeholders' needs
3. Define scope: developing a detailed project scope statement
4. Create WBS: subdividing project deliverables into smaller work units
5. Validate scope: formalizing the acceptance of the deliverables
6. Control scope: The ongoing process of monitoring and managing changes to the project scope

Plan scope management

Inputs:

- Project management plan
- Project charter
- Enterprise environmental factors
- Organizational process assets

Tools & Techniques:

- Expert judgment
- Meetings

Outputs:

- Scope management plan
- Requirement management plan

Collect requirements

The success of any project is directly related to the accurate definition and documentation of stakeholder needs. Requirements become the foundation of the work breakdown structure (WBS) in a future step.

Inputs:

- Scope management plan
- Requirement management plan
- Stakeholder management plan
- Project charter
- Stakeholder register

Tools & Techniques:

- Interviews
- Focus groups
- Facilitated workshops
- Group creativity techniques
- Group decision-making techniques
- Questionnaires and surveys
- Observations
- Prototypes
- Benchmarking
- Context diagrams
- Document analysis

Outputs:

- Requirement documentation
- Requirement traceability matrix

Define Scope:

At this second step, the requirements are compiled into a scope statement. An example of a scope statement might be to design a bridge that meets all state road design standards while providing adequate stream flow for a 1:100 year flood event. The abutment erosion of the bridge must be controlled, and environmental concerns such as fish passage and habitat must be accommodated.

Inputs

- Scope management plan
- Project charter
- Requirement documentation
- Organizational process assets

Tools & Techniques

- Expert judgment
- Product analysis
- Alternative generation
- Facilitated workshops

Outputs

- Project scope statement
- Project document updates

Create WBS

In this section, a detailed work breakdown structure is created, which is a breakdown of the deliverables into smaller, more manageable work packages. A WBS can take numerous forms, such as division by phases, deliverables, or subprojects. But regardless of how you structure it, the WBS should contain the man-hours, equipment, tools, contractor expenses, and any other item of cost. The WBS is not about the cost; pricing and cost control are part of the project cost management knowledge area. But the realization of cost helps to ensure you identify every part of a work package.

Inputs

- Scope management plan
- Project scope statement
- Requirement documentation
- Enterprise environmental factors
- Organization process assets

Tools & Techniques

- Decomposition
- Expert judgment

Outputs

- Scope baseline
- Project document updates

Validate Scope

Formalizing the project deliverables is a task in itself. In my engineering company, we sometimes give clients a scope statement and ask them to give verbal approval, particularly if it contains many non-standard things (i.e. not just another bridge). Other stakeholders, like landowners around a new development, are given scope statements that may or may not require acceptance depending on the circumstances and stage of the project.

Inputs

- Project management plan
- Requirement documentation
- Requirement traceability matrix
- Validated deliverables
- Work performance data

Tools & Techniques

- Inspection
- Group decision-making techniques

Outputs

- Accepted deliverables
- Change requests
- Work performance information
- Project document updates

Control Scope

The project scope must not only be well defined but well controlled. Like it was mentioned above, “scope creeps” trip up many projects, and there have been some ugly outcomes. Any changes in stakeholder expectations or requirements during the project’s execution must be integrated into a new scope statement and work breakdown structure. The associated cost, time, and resource changes must be itemized and managed.

Inputs

- Project management plan
- Requirement documentation
- Requirement traceability matrix
- Work performance data
- Organization process assets

Tools & Techniques

- Variance analysis

Outputs

- Work performance information
- Change requests

- Project management plan updates
- Project document updates
- Organizational process asset updates

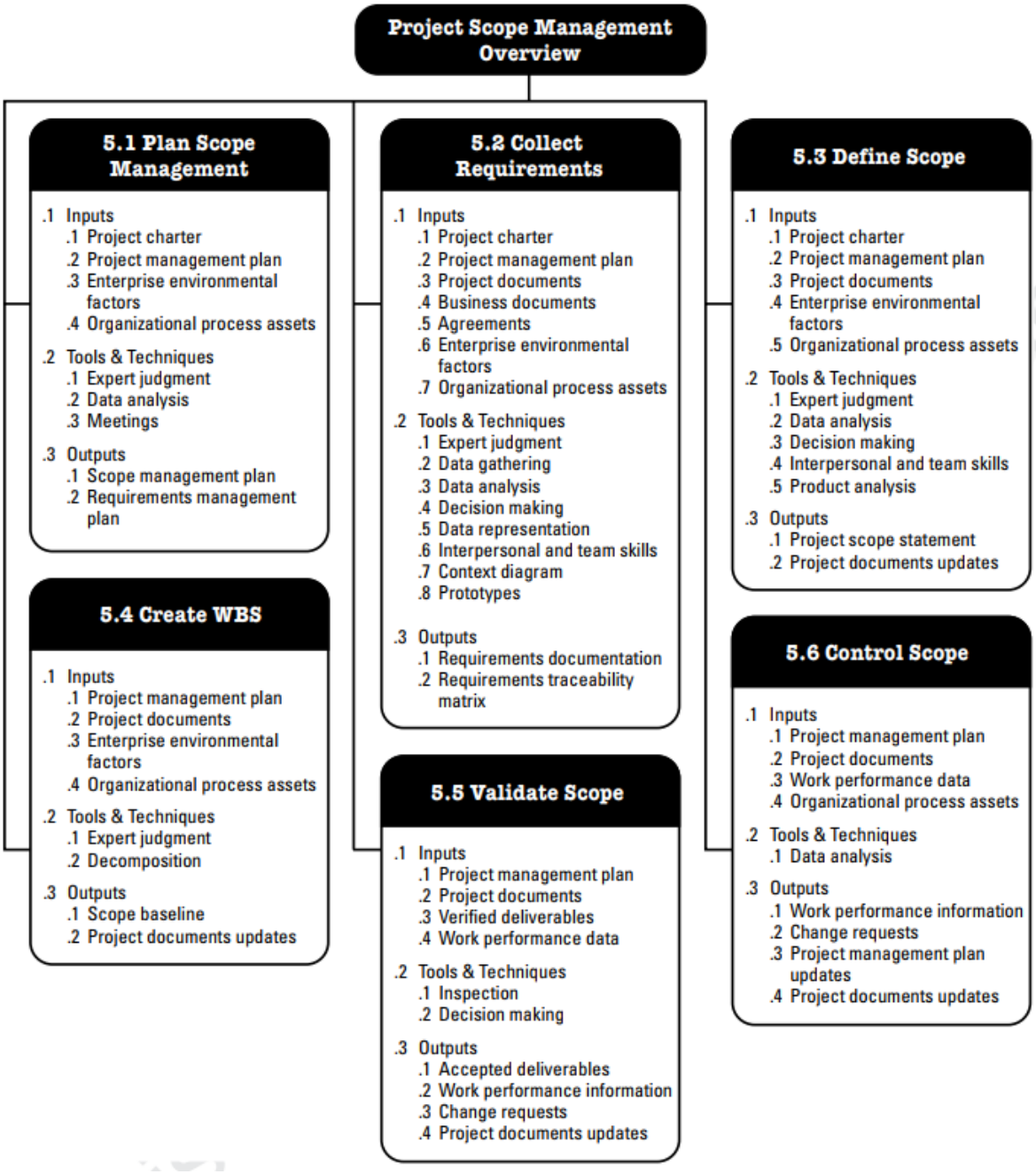


Figure 14. *Project Scope Management.*
Source: PMBOK® Guide (PMI, 2017).

2.2.5.3. Project Schedule Management

The project time management was converted to project schedule management in the latest PMBOK 6th Edition (PMI, 2017), and research indicated support for the name change, as project managers do not manage time. They define and manage the project schedule. Due to the shift in focus and renaming of project human resource management to project resource management, the estimate activity resources process was moved from this knowledge area to project resource management. Some agile concepts were incorporated into the develop schedule process.

Project scheduling provides a detailed plan that represents how the project will deliver the products, services, and results defined in the project scope. The project schedule is used as a tool for communication, managing stakeholder expectations, and as a basis for performance reporting. When possible, the detailed project schedule should remain flexible throughout the project to adjust for knowledge gained, increased understanding of the risk, and value-added activities.

Project schedule management is a process that refers to how the project manager manages his schedule for a project. It includes the time that is catered to complete each individual task pertaining to the project's objectives with the desired skills, tools, and techniques. In order to become a successful project manager, one has to clearly understand the activities of the project and should possess the necessary skills to plan, schedule, and control a project within its timeline. Apart from these skills, one must also be able to utilize schedule management tools to help them analyze, measure, and assess their schedule management techniques.

There are six important processes in project schedule management, and they are the following:

1. Plan schedule management
2. Define activities
3. Sequence activities
4. Estimate activity duration
5. Develop the schedule
6. Control the schedule

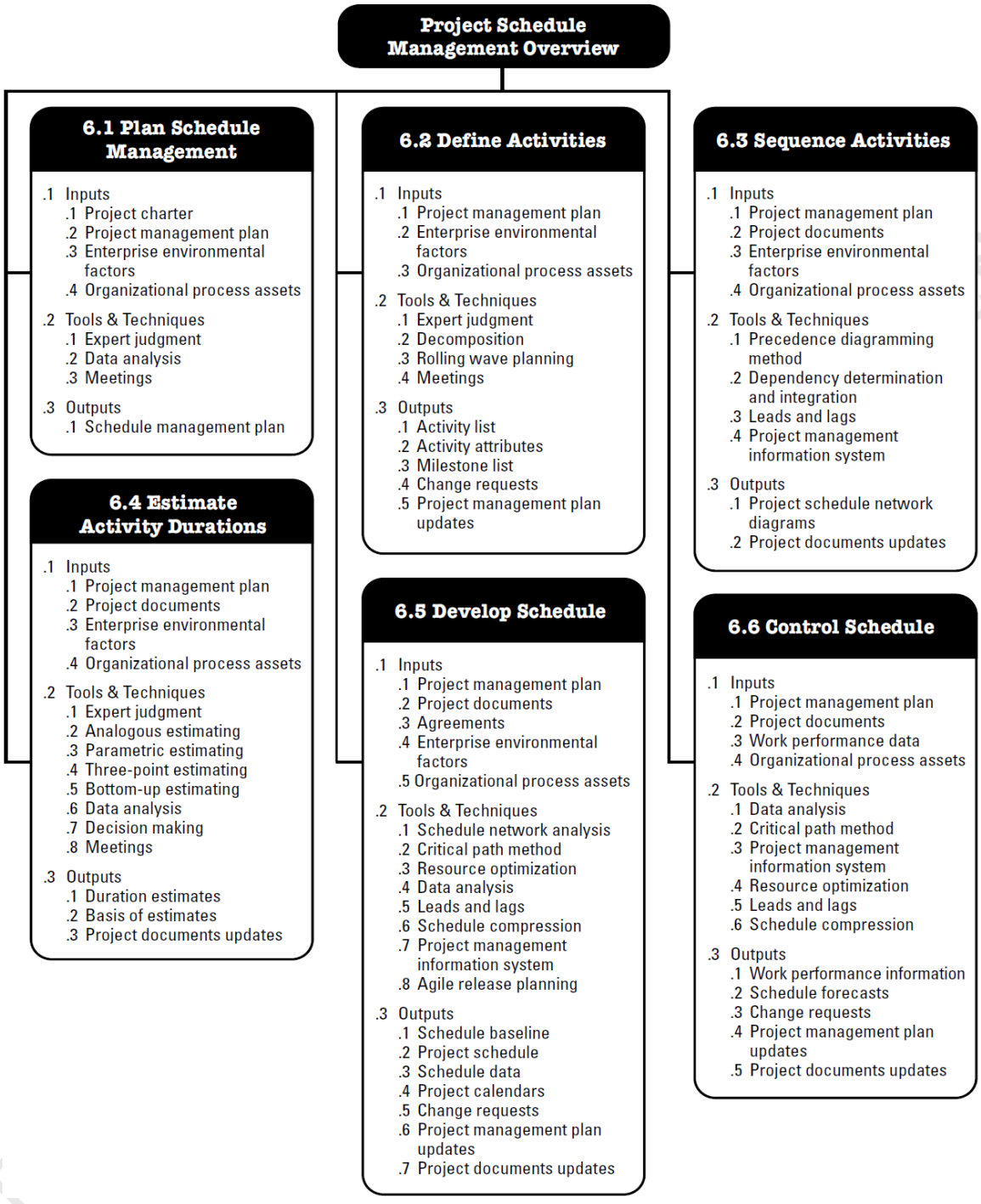


Figure 15. *Project Schedule Management.*
Source: PMBOK® Guide (PMI, 2017).

2.2.5.4. Project Cost Management

"Project Cost Management includes the processes involved in planning, estimating, budgeting, financing, funding, managing, and controlling costs so that the project can be completed within the approved budget" (PMI, 2017, p. 231). Figure 16 below provides an overview of the PMI's project cost management processes.

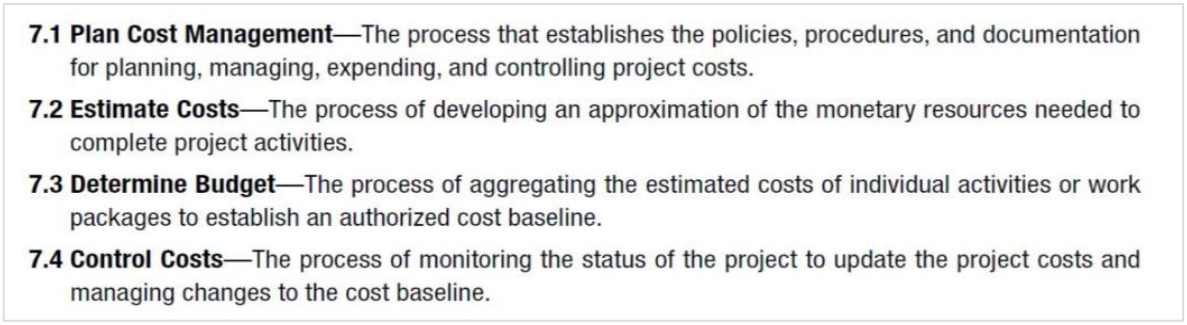


Figure 16. *Project Cost Management.*
Source: PMBOK® Guide (PMI, 2017).

2.2.5.5. Project Quality Management

"Project Quality Management includes the processes and activities of the performing organization that determine quality policies, objectives, and responsibilities so that the project will satisfy the needs for which it was undertaken" (PMI, 2017, p. 227). According to the PMI, the processes for the management of quality are identified in figure 17 below. Only process 8.1 will be used during project planning to produce the quality management plan that will guide the project's quality assurance.

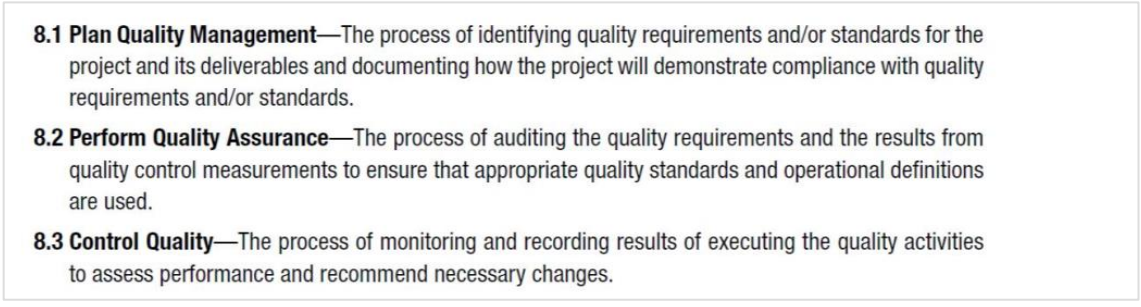


Figure 17. *Project Quality Management.*
Source: PMBOK® Guide (PMI, 2017).

2.2.5.6. Project Resource Management

In this method, it is all about how the project manager runs the project team. Firstly, it is to understand what resources (people, equipment, facilities, funding) are required to complete the project at hand and then organize a team to execute the work involved. This method mainly concentrates on how the project is carried out utilizing the desired resources to complete a project activity. The processes included in this knowledge area are the following:

1. Plan resource management
2. Estimate activity resources
3. Acquire resources
4. Develop the team
5. Manage the team
6. Control resources

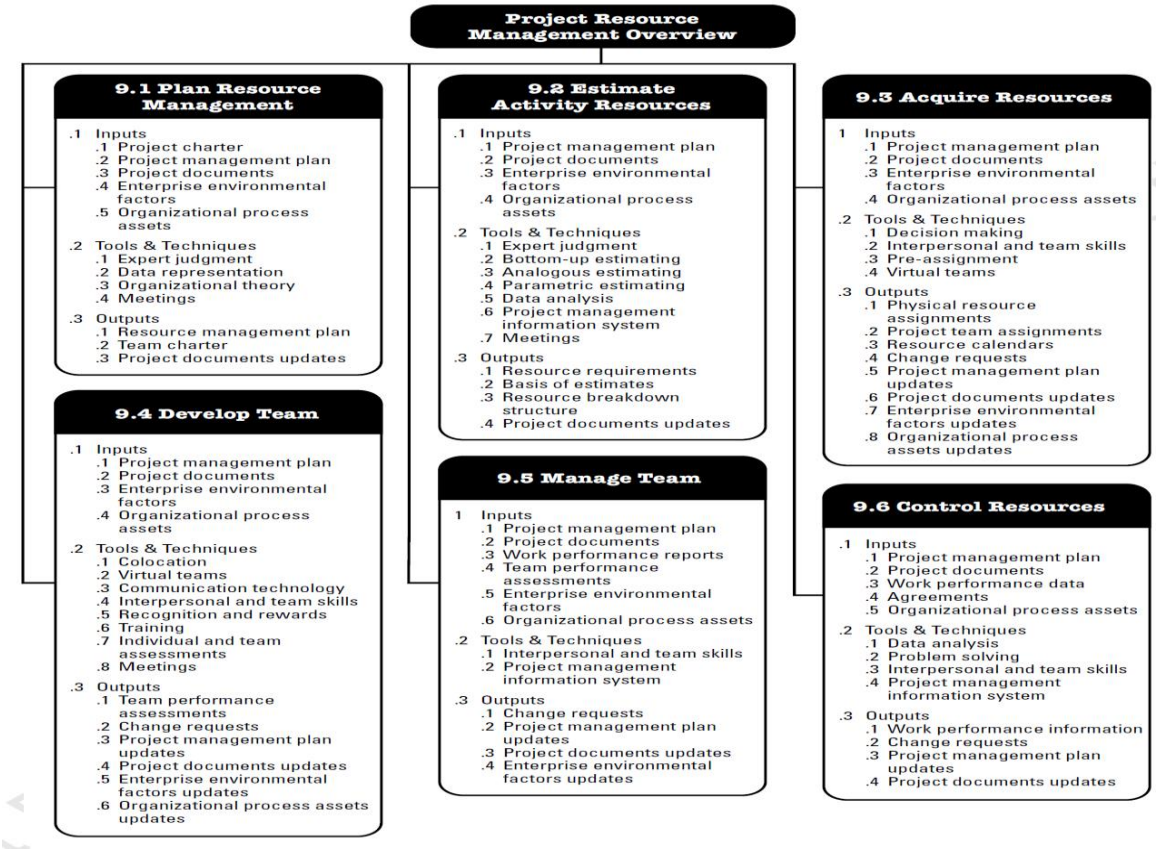


Figure 18. *Project Resource Management.*
Source: PMBOK® Guide (PMI, 2017).

2.2.5.7. Project Communication Management

As the name suggests, it is mostly about communication. Eighty percent of the project manager's job has to do with communication. Project communication is what keeps all team members on the same page. If there exists a gap in the communication level, the project can have a negative impact on its final product. Communication must take place between the project manager, his team members, and the stakeholders involved in the project. This knowledge area also includes three processes:

1. Plan communication management
2. Manage communication
3. Monitor communication

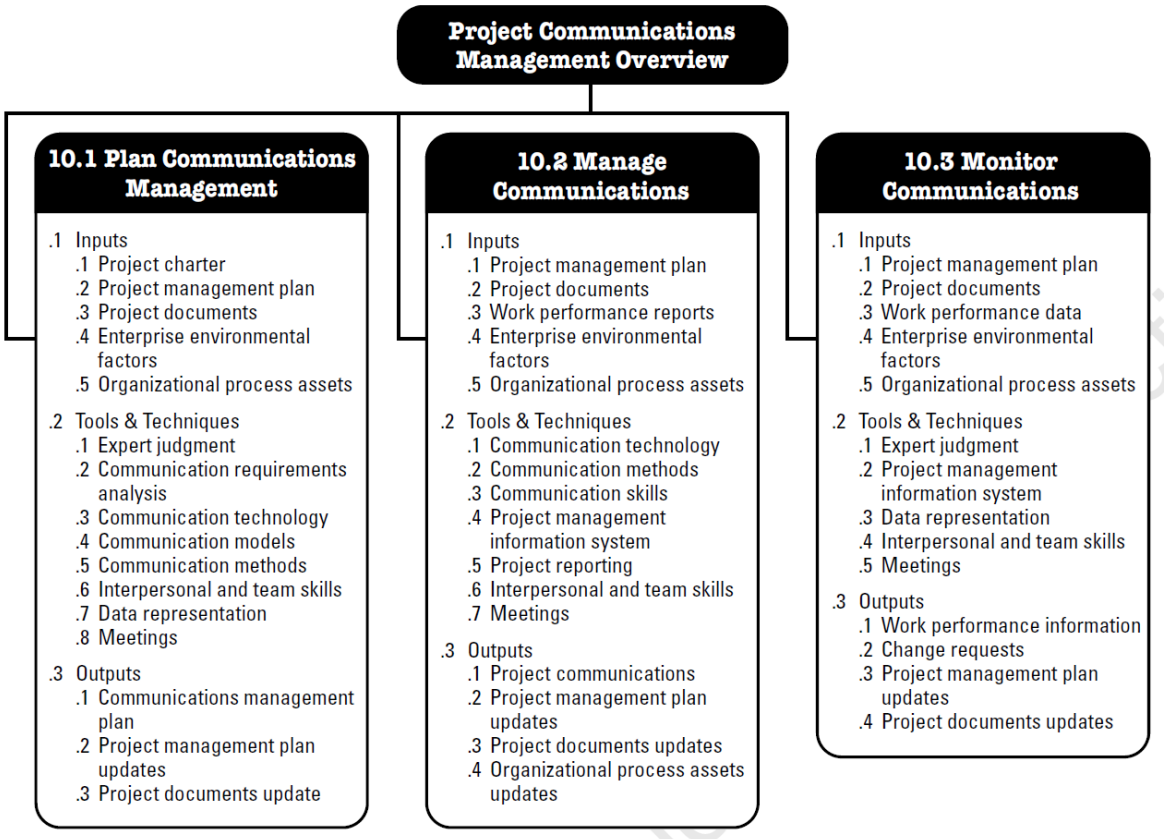


Figure 19. *Project Communication Management*
Source: PMBOK® Guide (PMI, 2017).

There should be planning to determine what information needs to be communicated to all stakeholders involved in the project. This information must be readily available to the stakeholders and generated in a timely fashion. The performance of the project must be accounted for by reporting the status of the project and measuring and forecasting the project. Effective communication must be carried out through the stakeholders so that all requirements are met and the existing issues are promptly resolved.

2.2.5.8. Project Risk Management

Initially, in the project risk management process, the project manager should conduct risk management work and then identify and analyze risks. Later, he/she should develop a risk response plan, which will control risks on an ongoing basis. These methods are introduced one by one to understand and assess the risks related to the project. It all depends on how one performs quantitative and qualitative risk assessments.

There are seven project management processes involved in the risk management knowledge area:

1. Plan risk management
2. Identify risks
3. Perform qualitative risk analysis
4. Perform quantitative risk analysis
5. Plan risk responses
6. Implement risk responses
7. Monitor risks

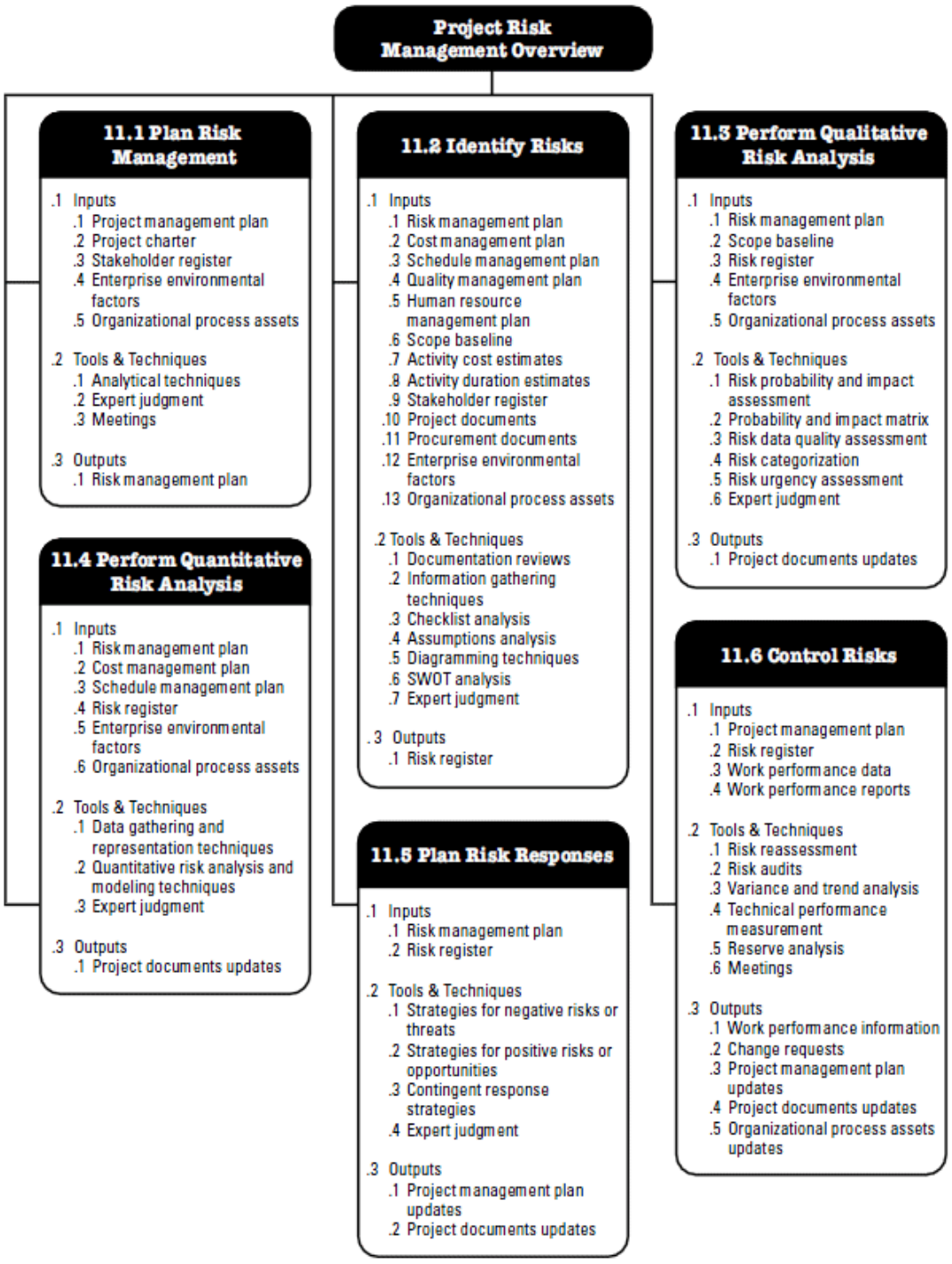


Figure 20. *Project Risk Management*
Source: PMBOK® Guide (PMI, 2017).

2.2.5.9. Project Procurement Management

The procurement management process is not something that the project manager has to do on all projects, but it is quite common. This knowledge area relates to the process of purchasing or acquiring products, services, or results from outside the project team. This project knowledge area keeps track of all project procurement and supplier work starting from planning what needs to be bought, to get involved in the surrendering and acquiring process, to executing the task of the supplier and closing the contract when the project is finished.

1. Project procurement management processes include the following:
2. Plan procurement management
3. Conduct procurements
4. Control procurements

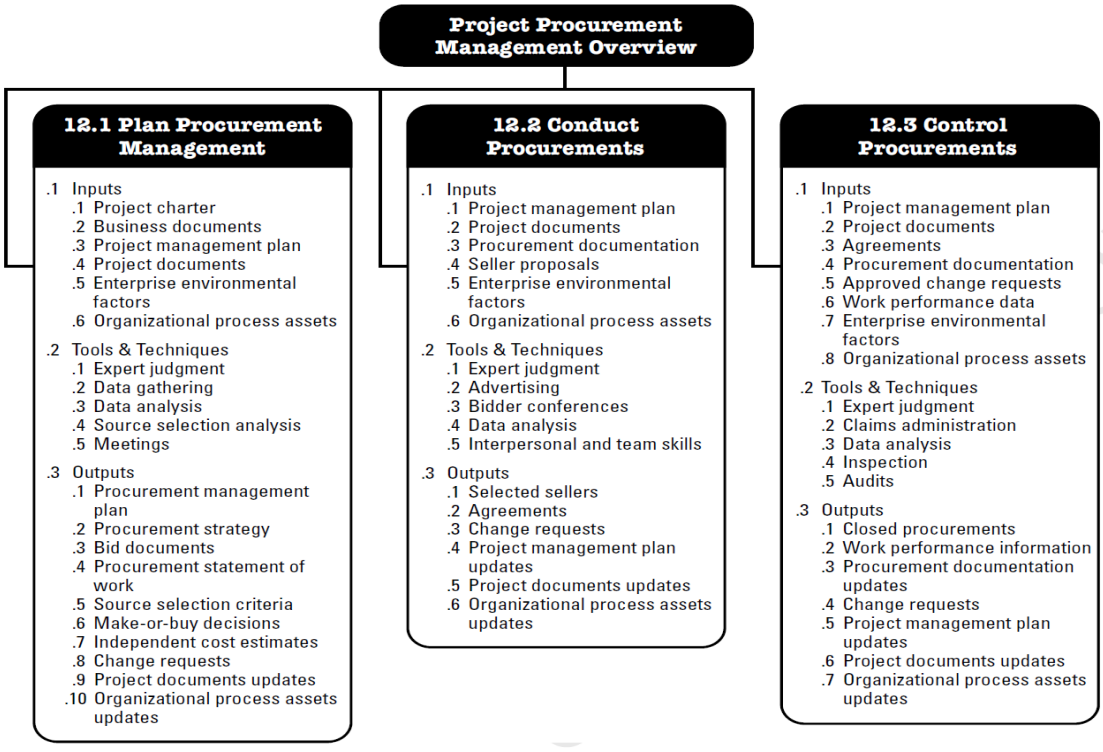


Figure 21. *Project Procurement Management*
Source: PMBOK® Guide (PMI, 2017).

2.2.5.10. Project Stakeholder Management

This is the last knowledge area in the PMBOK 6th Edition (PMI, 2017). Stakeholders play an important role in determining the success and failure of a project. Getting stakeholders involved in the project right from the beginning is crucial because they are the ones who decide on what changes are to be made to meet their requirements. If the project manager fails to involve them at the initial stage, the changes set forth by the stakeholders at a later stage will hamper the quality and value of the project.

The four processes involved in project stakeholder management are the following:

1. Identify stakeholders
2. Plan stakeholder engagement
3. Manage stakeholder engagement
4. Monitor stakeholder engagement

These project management knowledge areas cover a lot of ground. They have one or more processes belonging to the five project management process groups. When the project manager is aware of all project management knowledge areas, he can execute a project more efficiently and productively. The skills acquired by understanding these knowledge areas will assist the project manager to avoid crisis and scope deviation and enable him/her to make proactive decisions. Once the project manager thoroughly understands the concepts of the knowledge areas, he will become proficient at managing any given projects and the people involved in them.

Key terms that will be utilized to classify the stakeholders and their level of classification in the stakeholder management plan are the following:

- Power: It is a stakeholder's level of authority regarding the project outcome (PMI, 2017, p. 396).
- Interest: It is a stakeholder's level of concern regarding the project outcome (PMI, 2017, p. 396).

- Influence: It is a stakeholder's level of involvement in the project (PMI, 2017, p. 396).
- Impact: It is a stakeholder's ability to effect changes to the project's planning or execution (PMI, 2017, p. 396).
- Communication: It is "connecting with people by sending information" (Articulous Communications, 2015).
- Engagement: It is dialoguing with stakeholders to find out what matters most to them and incorporating their needs into the project (Articulous Communications, 2015).
- One-way communication: It is information sent in a straight line from the sender to the receiver. In this case, feedback is not given or required.
- Two-way engagement: It is communication between senders and receivers that involves listening by both parties. This dialogue occurs as a means of working together to solve a problem in a manner in which both parties can benefit from it.

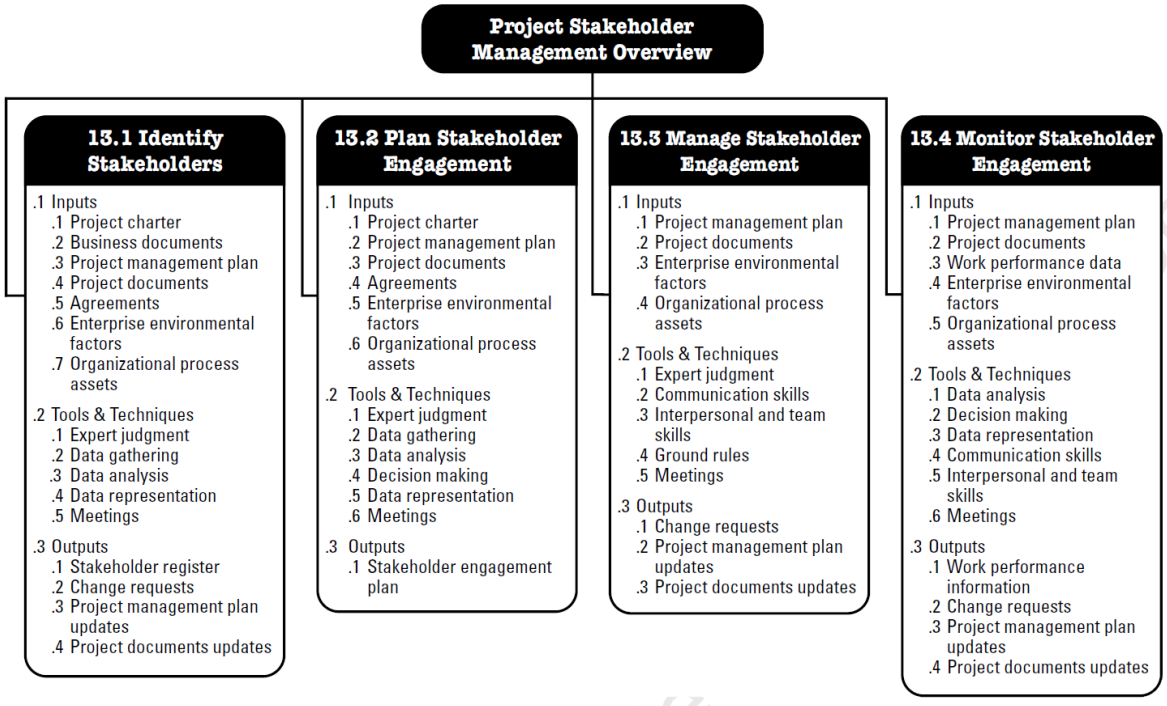


Figure 22. *Project Stakeholder Management.*
Source: PMBOK® Guide (PMI, 2017).

2.2.6. Other Applicable Theory/Concepts Related to the Projects

2.2.6.1. Sustainability

Sustainability is ensuring that our present needs are met by consuming resources in a responsible way, while endeavoring, all the time, to avoid precluding the future posterity of their ability to meet their own needs.

2.6.6.2. Conceptual/Program and Feasibility

This model uses the final vision of the building as the starting point to determine needs, goals, and objectives. Considerations include the building size, the number of rooms, how the space will be used, and even who will be using the space. This information is generally captured in a spreadsheet, listing each room, the critical information about those spaces, and the approximate square footage of each area.

2.2.6.3. Schematic Design

Schematic designs are drawings or sketches used to identify spaces, shapes, and patterns. Not every part of a construction project can be sketched, of course, but those that can be are done in this type of design. The drawings note materials, colors, and textures. These sketches can also capture floorplans, where structures like elevators will be placed and so on.

2.2.6.4. Preconstruction

Once the bids are accepted, but before ground is broken, you will have these three steps to work on. Assign a project manager. Do this if it has not already been determined. Sometimes, a project manager is on board early and participates in the first stages of a project, while other times, they are not hired until the design is complete.

Determine the rest of the personnel. Find a contract administrator; this is the person who helps the project manager. A superintendent is needed now as well, someone who keeps everything on schedule in terms of materials, deliveries, and equipment. They are also on site to deal with construction activities. Finally, you want to have a field engineer, which is more of an entry-level position to deal with

paperwork. Investigate the site. Check to see if anything is needed. The site must be ready for the construction, which might mean dealing with environmental issues, such as the suitability of the soil for construction.

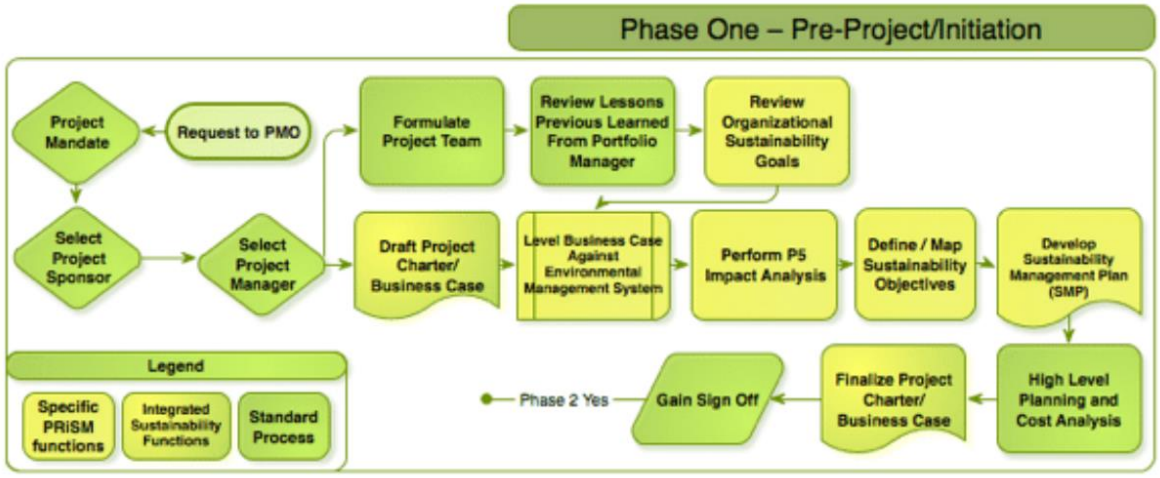


Figure 23. *Pre-Project Initiation.*
Source: Serrador (2012).

2.2.6.5. Accountability

A key to a successful construction project is accountability. There are many teams working separately but together for the greater good of the project. However, if team members are willing to take responsibility for those tasks assigned to them, the whole process can suffer. Strong leadership is the cure to this ill. With construction project management, risk management is even more important than on other projects. There are issues with safety that are more dangerous than risks that can impact other types of projects. Therefore, spending time with the team gathering their input as well as researching other sources is key to a strong risk management plan.

2.2.6.6. Sustainable Construction

What is sustainability in the context of building construction? Sustainable building construction means using natural resources, such as building materials, more efficiently, making processes more efficient, reducing pollution, and minimizing or eliminating waste.

2.2.6.6.1. Goals of Sustainable Construction

Robichaud & Anantatmula (2011) cited Kibert (2005), quoting the Conseil International du Batiment CIB, Sustainable Construction: Green Building Delivery and Design, described the goal of sustainable construction as:

> The goal of sustainable construction is to create and operate a healthy built environment based on resource efficiency and ecological design with an emphasis on seven core principles across the building's life cycle: reducing resource consumption, reusing resources, using recyclable resources, protecting nature, eliminating toxics/toxins, applying life cycle costing, and focusing on quality.

2.2.6.7. Environment and Climate Change

Green construction is a specialized and skilled profession, and the author has extensive experience in this field. The reference is designed to provide practical guidelines and essential insights in preparing competent and professional looking project analysis reports and project status reports. The book also provides numerous tips on how to phrase the language of reports in a manner that is articulate and clearly understood by real estate lenders and investors. It is also an indispensable companion for both information and stimulus.

2.2.6.7.1. Key Features

Provide details of including conscious efforts on green construction.

Include sample letters, reports, forms, and agreements for easy reference.

Practical guidelines for preparing property analysis and property status reports suitable for green construction

2.2.6.8. Energy

Worldwide, the number of jobs in the renewable energy sector is growing; it is now higher than 11 million, according to the International Renewable Energy Agency. That project appetite is expanding beyond traditional powerhouses such as the United States, China, and the European Union. Job growth is surging in Malaysia,

Thailand, and Vietnam. The Vietnamese government has created incentives for solar projects that will help meet the country's goal of increasing its solar capacity to 20 percent of national energy output by 2050.

Meanwhile, oil and gas organizations are fighting to stay competitive in this new era of energy consumption, despite volatile pricing, international trade disputes, and tightening worldwide regulations. Some are expanding and diversifying with renewable projects, while others are doubling down on digital technologies, such as initiatives to integrate artificial intelligence and drones into existing operations to drive efficiencies and boost bottom-line benefits.

- Commitment & accountability: It is recognizing the essential rights of all to healthy, clean, and safe environments, equal opportunity, fair remuneration, ethical procurement, and adherence to the rule of law.
- Ethics & decision making: It is supporting organizational ethics: decision making with respect for universal principles through the identification, mitigation, and prevention of adverse short and long-term impacts on society and the environment.
- Integrated & transparent: It is fostering the interdependence of economic development, social integrity, and environmental protection in all aspects of governance, practice, and reporting.
- Principal & value based: It is conserving and enhancing our natural resource base by improving the ways in which we develop and use technologies and resources.
- Social & ecological equity: It is assessing human vulnerability in ecologically sensitive areas and centers of population through demographic dynamics.
- Economic prosperity: It is establishing fiscal strategies, objectives, and targets that balance stakeholders’ needs, including immediate needs and those of future generations.

2.2.6.9. National Environmental Policy Act

The National Environmental Policy Act (NEPA) was signed into law on January 1, 1970. NEPA requires federal agencies to assess the environmental effects of their proposed actions prior to making decisions. The range of actions covered by NEPA is broad and includes the following:

- Making decisions on permit applications
- Adopting federal land management actions
- Constructing highways and other publicly owned facilities

Using the NEPA process, agencies evaluate the environmental and related social and economic effects of their proposed actions. Agencies also provide opportunities for public review and comment on those evaluations.

Title I of NEPA contains a Declaration of National Environmental Policy. This policy requires the federal government to use all practicable means to create and maintain conditions under which man and nature can exist in productive harmony. Section 102 in Title I of the act requires federal agencies to incorporate environmental considerations in their planning and decision-making through a systematic interdisciplinary approach.

Specifically, all federal agencies are to prepare detailed statements assessing the environmental impact and alternatives to major federal actions significantly affecting the environment.

These statements are commonly referred to as environmental impact statements (EIS) and environmental assessments (EA). Title II of NEPA established the president's council on environmental quality (CEQ) to oversee the NEPA implementation. The duties of CEQ include the following:

- Ensuring that federal agencies meet their obligations under NEPA
- Overseeing the federal agency implementation of the environmental impact assessment process
- Issuing regulations and other guidance to federal agencies regarding NEPA compliance

In 1978, CEQ issued regulations (40 CFR Parts 1500-1508) to implement NEPA. These regulations are binding on all federal agencies. The regulations address the procedural provisions of NEPA and the administration of the NEPA process, including the preparation of environmental impact statements. In addition to the CEQ NEPA regulations, CEQ has issued a variety of guidance documents on the implementation of NEPA.

Many federal agencies have also developed their own NEPA procedures that supplement the CEQ NEPA regulations. These NEPA procedures vary from agency to agency, since they are tailored for the specific mission and activities of the agency. Find NEPA procedures for specific federal agencies.

2.2.6.9.1. Lead Agency

The role of a federal agency in the NEPA process depends on the agency's expertise and relationship to the proposed action. The agency carrying out the federal action is responsible for complying with the requirements of NEPA. In some cases, there may be more than one federal agency involved in the proposed action. In this situation, a lead agency is designated to supervise the preparation of the environmental analysis. Federal agencies, together with state, tribal, or local agencies, may act as joint lead agencies.

2.2.6.9.2. Cooperating Agency

A federal, state, tribal, or local agency having special expertise with respect to an environmental issue or jurisdiction by law may be a cooperating agency. A cooperating agency has the responsibility to do the following actions:

Assist the lead agency by participating in the NEPA process at the earliest possible time to participate in the scoping process

Develop information and prepare the environmental analysis that the agency has special expertise in to make staff support available

2.2.6.9.3. Safety Certification

An SCMP was prepared for the project during the PE stage with support from WMATA. The SCMP addresses the requirements of the WMATA Safety and Security

Certification Program Plan and the FTA Handbook for Transit Safety and Security Certification. The primary interface by WMATA for safety and security-related issues is the Project Safety/Security Certification Working Group (SCWG). WMATA is an active participant on the SCWG, including representatives from system safety and risk management, metro transit police, and engineering service design and construction staffs. Administration and maintenance of the SCMP, including hazard and vulnerability identification and resolution for the project, is accomplished through the SCWG. The SCWG is also responsible for reviewing and recommending solutions to hazards and vulnerabilities on the existing metrorail system that may be applicable to the project.

The WMATA SCWG representatives are responsible for overseeing the certification effort on behalf of the WMATA Safety and Security Certification Review Committee (SCRC). The WMATA project representatives report on certification progress and SCWG activities to the respective departmental members of the SCRC. The SCWG representatives are also responsible for making a recommendation to the SCRC when it is appropriate for the project to enter the pre-revenue stage.

The SCRC is responsible for reviewing certification reports and all related documentation. Upon acceptance of the report findings by the SCRC, WMATA will initiate pre-revenue stage activities. Once the project is in the pre-revenue stage, the SCRC is responsible for all certification activities.

The SCRC is also responsible for overseeing all certification activities in accordance with the WMATA Safety and Security Certification Program Plan. Once the appropriate level of certification is achieved, the SCRC will forward a recommendation to enter the revenue service to the WMATA Safety and Security Executive Committee. Each stage of the safety and security certification program, from design through start-up and revenue testing, will be periodically audited by WMATA project representatives to ensure that the Safety and Security Certification Program Plan is being properly implemented and effective. The audit findings will be reported to the SCRC and included in the WMATA annual internal safety audit report to the TriState Oversight Committee (TOC).

2.2.6.10. Pre-Revenue Stage

The pre-revenue stage of the project will be the responsibility of WMATA. The pre-revenue stage will be safety and security-certified in accordance with the WMATA Safety and Security Certification Program Plan. At the conclusion of the pre-revenue stage of the project, WMATA will prepare a final safety and security certification report and submit it to the Safety and Security Executive Committee for approval. The approved report will be transmitted to the TOC under the signature of the WMATA general manager. The TOC may also conduct its own independent operational readiness review of the new line segment. WMATA will be responsible for coordinating all TOC activities.

During the pre-revenue stage of the project, operating procedures and plans will be tested for effectiveness under simulated operating conditions for normal, abnormal, and emergency situations. Emergency drills will also be held at selected sites and coordinated by the system safety and risk management, department of operations (OPER), and metro transit police and will involve external emergency response agencies that may respond to an incident on the rail extension. The drills will verify the adequacy of WMATA emergency response plans and procedures and will ensure that outside emergency response personnel are prepared to adequately respond to emergencies on the new alignment.

In addition, a final “walk-through inspection” of completed facilities and systems will be performed. At the conclusion of the pre-revenue stage, a certificate of conformance will be prepared and submitted to the SCRC for approval and also a recommendation for a certification of system compliance to be issued.

2.2.6.11. PESTLE Analysis

All the aspects of this technique are crucial for any industry a business might be in. More than just understanding the market, this framework represents one of the vertebras of the backbone of strategic management that not only defines what a company should do but also accounts for an organization’s goals and the strategies stringed to them.

It may be that the importance of each of the factors is different from different kinds of industries, but it is imperative to any strategy a company wants to develop that they conduct the PESTLE analysis, as it forms a much more comprehensive version of the SWOT analysis. It is very critical for one to understand the complete depth of each letter of the PESTLE.

1. Political factors: These factors determine the extent to which a government may influence the economy or a certain industry.
2. Economic factors: These factors are determinants of an economy's performance that directly impacts a company, and they have resonating long-term effects.
3. Social factors: These factors scrutinize the social environment of the market and gauge determinants like cultural trends, demographics, population analytics, etc.
4. Technological factors: These factors pertain to innovations in technology that may affect the operations of the industry and the market favorably or unfavorably. This refers to automation, research and development, and the amount of technological awareness that a market possesses.
5. Legal factors: These factors have both external and internal sides. There are certain laws that affect the business environment in a certain country, while there are certain policies that companies maintain for themselves. Legal analysis takes into account both of these angles and then charts out the strategies in light of these legislations.
6. Environmental factors: These factors include all those that influence or are determined by the surrounding environment. This aspect of the PESTLE is crucial for certain industries, for example tourism, farming, agriculture, etc. Factors of a business environmental analysis include but are not limited to climate, weather, geographical location, global changes in climate, environmental offsets, etc.

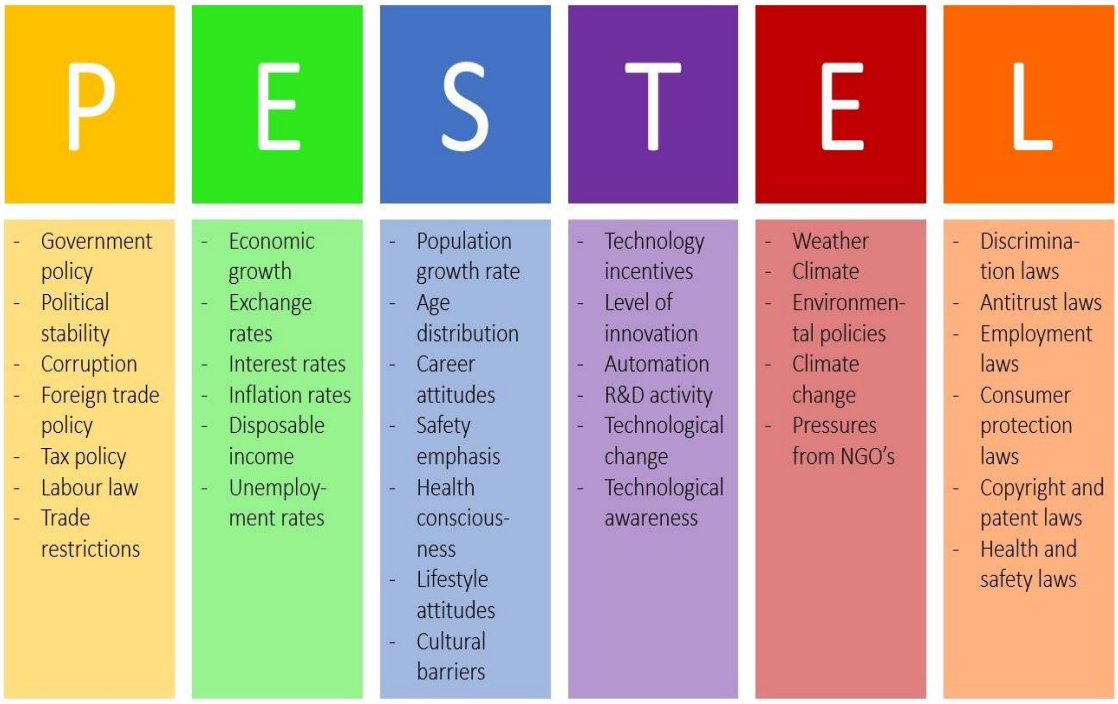


Figure 24. *PESTEL Analysis author pestle analysis.*
Source: Professional Academy (n.d.)

CHAPTER III. METHODOLOGICAL FRAMEWORK

3.1. Information Sources

An information source is “a source of information for somebody, i.e. anything that might informs a person about something on provide knowledge to somebody? Information sources may be observations, people speeches, documents, pictures, organizations etc” (Library and Information Science Network, 2018, para. 2).

Library and Information Science Network (2018) stated:

Different epistemologies have different views regarding the importance of different kind of information sources. Empiricism regards sense data as the ultimate information sources, while other epistemologies have different views … The various types of information sources can be divided into two broad categories.

A) Documentary sources

B) Non-Documentary sources (para. 3)

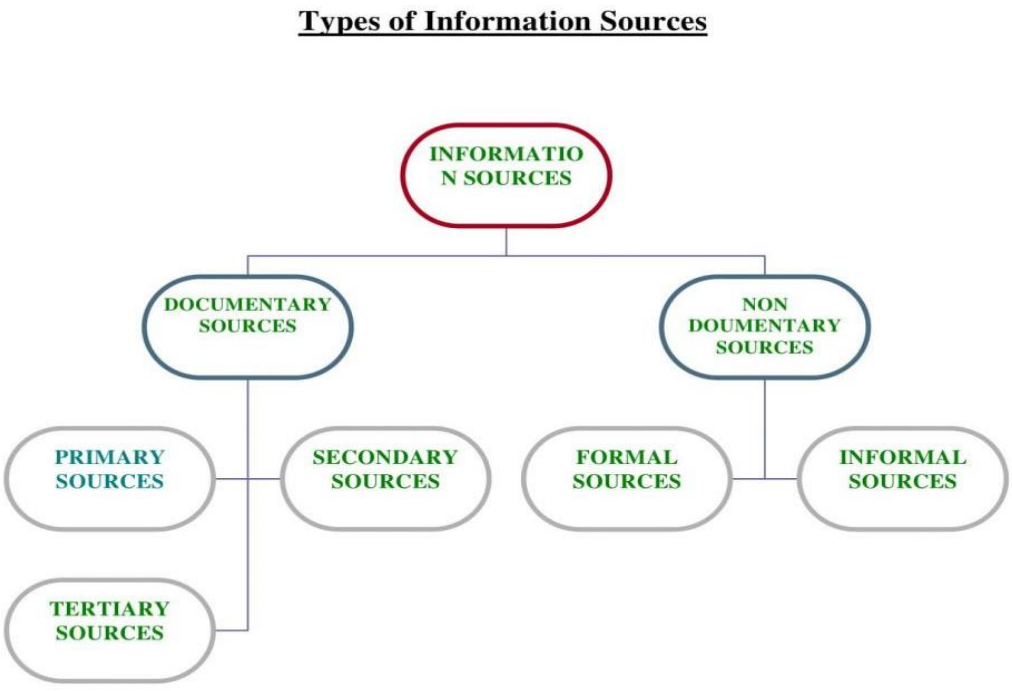


Figure 25. *Types of Information Sources*
Source: Library and Information Science Network (2018).

3.1.1. Primary Sources

Primary sources of information, according to Library and Information Science Network (2018), are “the first published records of original research and development or description of new application or new interpretation of an old theme or idea. There are original documents representing unfiltered original ideas” (para. 5). Examples of primary sources:

- Books
- Periodicals
- Conference papers
- Research monographs
- Research reports

They constitute the latest available information. A researcher producing new information can make it available to the community through primary sources. Often, it may be the only source of information in existence. Primary sources are unorganized sources, which are rather difficult to use by them. Secondary sources help us to use them. They are important sources of information. A subject becomes a discipline when independent primary sources begin to be produced in that area. The rate of growth of a discipline to a large extent depends on the amount of literature being produced in the form of primary sources reporting development in the concerned field. Primary source is a term used in several disciplines to describe source material that is closest to the person, information, period, or an idea being studied…In journalism, a primary source can be a person with direct knowledge of a situation or a document created by such a person. Primary sources are distinguished from secondary sources, which cite, comment on, or build upon primary sources; though the distinction is not a sharp one. «Primary and secondary are relative terms, with sources judged primary or secondary according to specific historical contexts and what is being studied»… (Library and Information Science Network, 2018, para. 6-10)

For the development of the final graduation project, the primary information sources will be considered from several primary approaches that will be used as main sources from Dulles Corridor Metrorail Project. (n.d.a). Published in December 2004 and the Federal Transit Administration (FTA) Issued Its Record of Decision Approving the Environmental Process in March 2005. Primary sources may also include surveys, interviews, observations, research, historical and legal documents, financial data published in the Dulles metrorail website, accounts, experiment results, statistical data, pieces of creative writing, audio and video recordings, speeches, art objects, Internet searches, fieldwork, and personal communication via email, blogs, and newsgroups.

3.1.2. Secondary Sources

According to Library and Information Science Network (2018), secondary sources of information are:

Those which are either compiled from or refer to primary sources of information. The original information having been casually modified selected or reorganized to serve a definite purpose for group of users. Such sources contain information arranged and organized based on some definite plan. These contain organized repackaged knowledge rather than new knowledge. Information given in primary sources is made available in a more convenient form. Due to their very nature, secondary sources are more easily and widely available than primary sources. These not only provide digested information but also serve as bibliographical key to primary sources of information. The primary sources are the first to appear, these are followed by secondary sources. It is difficult to find information from primary sources directly. Therefore, one should consult the secondary sources in the first instance, which will lead one to specific primary sources (para. 11).

Types of secondary sources of information: Index type, Survey type and Reference type.

Chart 1. *Information Sources*

SL NO.	Objectives	Primary Information sources	Secondary Information sources
1.	To construct a scope management plan to ensure that the requisite cost planning, resource allocation, and stakeholder engagement are done during the project life	Surveys, interviews, observations, research, historical and legal documents, financial data published in the Dulles metrorail website, accounts, experiment results, statistical data, pieces of creative writing, audio and video recordings, speeches, and art objects. Internet searches, fieldwork, and Internet communication obtained through searches, email, blogs, and newsgroups are also considered as primary sources here.	The PMBOK® Guide, PMI database, and other related PMI guideline references
2.	To create a cost management plan to ensure a more sustainable cash flow and that adequate funds are allocated to the Dulles metrorail project construction	Dulles Metrorail Project Public Documents (Dulles Corridor Metrorail Project, n.d.c). Comprehensive monthly reports issued by the Dulles Corridor Metrorail Project by the Metropolitan Washington Airports Authority and the Washington, D.C. agreement to fund the capital cost of construction of the metrorail in the Dulles Corridor. Dulles Corridor Metrorail Project, A Cost-Benefit Analysis by Lauren Donnelly	The PMBOK® Guide (PMI, 2017), drawings, historical data, GPM® Reference Guide to Sustainability in Project Management Project management and the planning process for construction management
3	To develop a project schedule management plan for the activity attributes, activity lists, basis of estimates, duration estimates, project calendars, project schedule, project schedule network diagram, schedule data, and schedule forecasts	Dulles Metrorail Project Public Documents (Dulles Corridor Metrorail Project, n.d.c). *The capability of the airports authority and project team*. (Metropolitan Washington Airports Authority [MWAA], n.d.b).	The PMBOK® Guide (PMI, 2017) and PMI database

SL NO.	Objectives	Primary Information sources	Secondary Information sources
4	To develop quality management plan to ensure that the quality objectives are met throughout the project and the results meet expectations for approval within the time, cost, and scope constraints	Dulles Metrorail Project Public Documents (Dulles Corridor Metrorail Project, n.d.c). Surveys, interviews, observations, research, historical and legal documents, financial data published in the Dulles metrorail website, accounts, experiment results, and statistical data	The PMBOK® Guide (PMI, 2017), historical data, the PMI guide for sustainability in project management, and the GPM® Reference Guide.
5	To create a sustainable resource management plan for assigning resources to work packages in a manner that complies with international laws and conventions	*Functional duties and engineering of the Dulles Corridor Metrorail Project.* (Metropolitan Washington Airports Authority [MWAA], n.d.a). Management's rights to assign or reassign duties and responsibilities - Human Resource Management Guide.	The PMBOK® Guide (PMI, 2017), historical data, the PMI guide for sustainability in project management, and the GPM® Reference Guide.
6.	To develop a sustainable communication management plan for clearly defining the project communication strategies and line of reporting authority	*Strategic Planning Framework for Mega Projects Traffic Management Showcases from Dulles Metrorail Corridor and London Crossrail* (Kelleny, 2016). Surveys, interviews, observations, research, historical and legal documents, financial data published in the Dulles metrorail website, accounts, experiment results, and statistical data	The PMBOK® Guide (PMI, 2017), historical data, the PMI guide for sustainability in project management, and the GPM® Reference Guide.
7.	To develop a stakeholder management plan that identifies key stakeholders and their level of interest and analyses how their influence might impact the project	Surveys, interviews, observations, research, historical and legal documents, financial data published in the Dulles metrorail website, accounts, experiment results, and statistical data	The PMBOK® Guide (PMI, 2017), the PMI database, and other related PMI guideline references

SL NO.	Objectives	Primary Information sources	Secondary Information sources
8.	To create a sustainable risk management plan that identifies risks and risk responses for risks directly related to the project and those that have sustainability implications	Dulles Metrorail Project Public Documents (Dulles Corridor Metrorail Project, n.d.c). Surveys, interviews, observations, research, historical and legal documents, financial data published in the Dulles metrorail website, accounts, experiment results, and statistical data	The PMBOK® Guide (PMI, 2017), the PMI database, and other related PMI guideline references
9.	To develop sustainable procurement plan for identifying and assigning contracts to suppliers who are able to procure sustainable goods and services	*The capability of the airports authority and project team*. (Metropolitan Washington Airports Authority [MWAA], n.d.b). Dulles Metrorail Project Public Documents (Dulles Corridor Metrorail Project, n.d.c). Surveys, interviews, observations, research, historical and legal documents, financial data published in the Dulles metrorail website, accounts, experiment results, and statistical data	The PMBOK® Guide (PMI, 2017), the PMI database, and other related PMI guideline references

3.2. Research Methods

Research methods are the strategies, processes, or techniques utilized in the collection of data or evidence for analysis to uncover new information or create better understanding of a topic. There are different types of research methods that use the following elements:

3.2.1. Analytical Research

"Analytical research, as a style of qualitative inquiry, draws from the disciplines of philosophy (the meaning of concepts), history, and biography" (McMillian & Schumacher, 1997, p. 464).

Difference from ethnography: It is non-interactive document research. "Analytical research describes and interprets the past or recent past from selected sources" (McMillian & Schumacher, 1997, p. 464). The sources may be documents preserved in collections and/or participants' oral testimonies (oral histories).

3.2.2. Quantitative Research

According to Snap Surveys (n.d.):

Quantitative research is used to quantify the problem by way of generating numerical data or data that can be transformed into usable statistics. It is used to quantify attitudes, opinions, behaviors, and other defined variables – and generalize results from a larger sample population. Quantitative research uses measurable data to formulate facts and uncover patterns in research. Quantitative data collection methods are much more structured than qualitative data collection methods. Quantitative data collection methods include various forms of surveys – online surveys, paper surveys, mobile surveys and kiosk surveys, face-to-face interviews, telephone interviews, longitudinal studies, website interceptors, online polls, and systematic observations. (para. 3)

3.2.3. Qualitative Research

According to Denzin and Lincoln (1994, as cited in SimplyPsychology, n.d.):

> Qualitative research is multimethod in focus, involving an interpretive, naturalistic approach to its subject matter. This means that qualitative researchers study things in their natural settings, attempting to make sense of, or interpret, phenomena in terms of the meanings people bring to them.
>
> The aim of qualitative research is to understand the social reality of individuals, groups, and cultures as nearly as possible as its participants feel it or live it. Thus, people and groups are studied in their natural setting. (para. 4)

3.2.4. Descriptive Research

Formplus Blog (2020) stated:

Descriptive research is a type of research that describes a population, situation, or phenomenon that is being studied. It focuses on answering the how, what, when, and where questions of a research problem, rather than the why. This is mainly because it is important to have a proper understanding of what a research problem is about before investigating why it exists in the first place…Descriptive research is classified into different types according to the kind of approach that is used in conducting it.

Descriptive survey: Descriptive survey research uses surveys to gather data about varying subjects. This data aims to know the extent to which different conditions can be obtained among these subjects.

Descriptive normative survey: This is an extension of the descriptive survey, with the addition being the normative element. In the descriptive normative survey, the results of the study should be compared with the norm.

Descriptive status: This is a quantitative description technique that seeks to answer questions about real-life situations. For example, a researcher researching the income of the employees in a company and the relationship with their performance.

Descriptive analysis: The descriptive analysis method of research describes a subject by further analyzing it. (para. 3-5)

Chart 2. *Research Methods*

Objectives	**Analytical research method**	**Quantitative research method**	**Qualitative research method**	**Descriptive research method**
To create a sustainable scope management plan for the identification of key stakeholders and their unique requirements and expectations	The analytical method will be employed by using facts or information from the sources identified in Chart 1, objective 1 above to drive decision making when creating the project scope management plan.	This unbiased, methodical sampling method analyses statistical records to describe variables to determine contributory proceedings between causal scope factors and to facilitate the best projections of future outcomes in this knowledge area.	This method provides insight into various key components of this knowledge area; it is a basis for further research and offers an indication of how and why decisions are made about scope management.	This method will provide a thorough explanation of the numerous components of the scope management plan as they presently exist.
To create a schedule management plan to support the development and management of a project schedule that ensures the project is completed within the time constraints	A schedule will be developed from data observed from drawings and other construction documents as well as interviews with experts and stakeholders.	This unbiased, methodical sampling method analyses statistical records to describe variables to determine contributory proceedings between causal time factors and to facilitate the best projections of future outcomes in this knowledge area.	This method provides insight into various key components of this knowledge area; it is a basis for further research and offers an indication of how and why decisions are made about time management.	This method will provide a thorough explanation of the numerous components of the time management plan as they presently exist.

Objectives	Analytical research method	Quantitative research method	Qualitative research method	Descriptive research method
To create a cost management plan to define the processes for developing and managing the project budget that ensures the project is completed within the budget constraints	A budget will be developed from data observed from construction documents as well as interviews with experts and stakeholders.	This unbiased, methodical sampling method analyses statistical records to describe variables to determine contributory proceedings between causal cost factors and to facilitate the best projections of future outcomes in this knowledge area.	This method provides insight into various key components of this knowledge area; it is a basis for further research and offers an indication of how and why decisions are made about cost management.	This method will provide a thorough explanation of the numerous components of the cost management plan as they presently exist.
To develop a quality management plan to identify the quality requirements for the project in order to ensure the results meet expectations for approval within the time, cost, and scope constraints	A quality management plan will be developed from data observed from construction documents as well as interviews with experts and stakeholders.	Planning for quantitatively managing quality for a project, you face two key issues: first, setting the quality goal and second, predicting defect levels at intermediate milestones that can be used for quantitatively monitoring the progress toward the goal.	Explicitly addressed quality assurance within a qualitative paradigm. A meta-narrative approach was used to review and synthesize the literature.	To better coordinate and direct the project activities to meet construction and regulatory requirements and improve the project effectiveness and efficiency on a continuous basis

Objectives	Analytical research method	Quantitative research method	Qualitative research method	Descriptive research method
To create a resource management plan to ensure that all human resources are identified and managed effectively to complete the project within time, cost, and scope constraints	A resource plan will be developed from data observed from construction documents as well as interviews with experts and stakeholders.	Quantitative research involves measurable, objective subject matter and can demonstrate the significance one subject may have with another.	The empirical findings from qualitative interviews with leaders, human resource managers, line managers, and employees across five case study banks reveal that these processes are dependent on the enactment and contextualization by the actors involved in the process.	Planning is the basis of managerial elements and is a process within the framework of which organizations combine and merge all their activities and efforts with regard to the desired goals, the ways for achieving them, and how they are met, and the purpose behind its implementation is the achievement of organizational results.
To develop a communication management plan to ensure the timely and effective communication of the project status and other key information	A communication plan will be developed from data observed from construction documents as well as interviews with experts and stakeholders.	This unbiased, methodical sampling method analyses statistical records to describe variables to determine contributory proceedings between causal communication factors and to facilitate the best projections of future outcomes in this knowledge area.	This method provides insight into various key components of this knowledge area; it is a basis for further research and offers an indication of how and why decisions are made about communication management.	This method will provide a thorough explanation of the numerous components of the communication management plan as they presently exist.

Objectives	**Analytical research method**	**Quantitative research method**	**Qualitative research method**	**Descriptive research method**
To create a risk management plan to identify and examine risks to the successful completion of the project and develop plans to minimize the likelihood of the risks	A risk management plan will be developed from data observed from construction documents as well as interviews with experts and stakeholders.	The quantitative risk assessment method uses numerical measures to estimate the values of occurrence frequency of incidents and the probability or susceptibility of events. These values, when expressed in numerical figures, are then used to calculate the risks associated with any infrastructure or event.	There are several techniques when performing qualitative risk analysis to determine the probability and impact of risks, including the following: brainstorming, interviewing, the Delphi technique, historical data, and the strength, weakness, opportunity, and threat analysis (SWOT analysis).	Risk management is the process of identifying risks, assessing risks, and taking steps to reduce risks to an acceptable level. The risk management approach determines the processes, techniques, tools, and team roles and responsibilities for a specific project.
To develop a procurement management plan to be used to obtain products, services, or results required by the project	A procurement plan will be developed from data observed from construction documents as well as interviews with experts and stakeholders.	Quantitative (QR) research in the field of purchasing management. Furthermore, giving quantitative research the attention it deserves will help purchasing management to develop to an established field. This is the rationale behind our research project *Quantitative analysis of strategic and tactical purchasing decisions*. Subsequently, this leads to the following main goal for our project.	This qualitative focus group study was designed to capture the vendors' perspective on issues, challenges, and opportunities arising across the entire system's life cycle from the very early stages at which the construction plans the introduction of a project management plan system.	The procurement management plan is a part of the overall project management plan. The process describes how items will be procured during the project and the approach to use and manage vendors on the project. Specific areas to describe include the procurement process.

Objectives	Analytical research method	Quantitative research method	Qualitative research method	Descriptive research method
To develop a stakeholder management plan to identify and support all project stakeholders to ensure effective stakeholder engagement	A stakeholder management plan will be developed from data observed from construction documents as well as interviews with experts and stakeholders.	This unbiased, methodical sampling method analyses statistical records to describe variables to determine contributory proceedings between causal stakeholder factors and to facilitate the best projections of future outcomes in this knowledge area.	This method provides insight into various key components of this knowledge area; it is a basis for further research and offers an indication of how and why decisions are made about stakeholder management.	This method will provide a thorough explanation of the numerous components of the stakeholder management plan as they presently exist.

3.3. Tools

A Guide to the Project Management Body of Knowledge (PMBOK® Guide) includes many proven techniques and tools designed to facilitate the processes used to manage projects. The tips and tools presented here are designed to supplement those processes and are accompanied by a practical application or «war story» to illustrate how to successfully use these concepts. Wrike (n.d.) stated:

Project management tools are made to be completely customizable so they can fit the needs of teams of different sizes and with different goals.

Project management tools are usually defined by the different features that are offered. They include, but are not limited to the following:

-Planning/scheduling - Project management tools allow you to plan and delegate work all in one place with tasks, subtasks, folders, templates, workflows, and calendars.

-Collaboration - Email is no longer the only form of communication. Use project management tools to assign tasks, add comments, organize dashboards, and for proofing & approvals.

-Documentation - Avoid missing files with file management features: editing, versioning, & storage of all files.

-Evaluation - Track and assess productivity and growth through resource management & reporting. (para. 2-3)

3.3.1. Project Management Tools

Haughey (n.d.) stated:

Gantt chart: A Gantt chart is a popular project management bar chart that tracks tasks across time. When first developed in 1917, the Gantt chart did not show the relationships between the tasks. Since then, it has become common to track both time and interdependencies between tasks, which is now its everyday use. Since their first introduction, Gantt charts have become an industry standard. They are an important project management tool used for showing the phases, tasks, milestones, and resources needed as part of a project.

Logic network: A Logic Network indicates the sequence of activities in a project over time. It shows which activity logically precedes or follows another activity. It can be used to identify the milestones and critical path of a project. It will help you understand the dependencies in your project, timescale, and its workflow. Valuable information that you may otherwise overlook can be revealed using this technique.

PERT chart: The Program Evaluation and Review Technique, commonly abbreviated to PERT is a model for project management developed by the United States Department of Defense's US Navy Special Projects Office in 1958 as part of the Polaris mobile submarine-launched ballistic missile project. PERT is a method for analyzing the tasks involved in completing a given project, especially the time needed to complete each task and identifying the minimum time required to complete the total project.

Product breakdown structure (PBS): In project management, a Product Breakdown Structure (PBS) is an exhaustive, hierarchical tree structure of components that make up a project deliverable, arranged in whole-part relationship. A PBS can help clarify what is to be delivered by the project and can contribute to building a work breakdown structure.

Work breakdown structure (WBS): The United States Department of Defense (DOD) created the Work Breakdown Structure concept as part of the Polaris mobile submarine-launched ballistic missile project. A Work Breakdown Structure is a hierarchical decomposition of the deliverables needed to complete a project. It breaks the deliverables down into manageable work packages that can be scheduled, costed, and have people assigned to them. A Work Breakdown Structure is a standard project management tool and the basis for much project planning. (para. 1-5)

Chart 3. *Tools*

Objectives	Tools
To construct a scope management plan and to ensure that the necessary cost planning, resource allocation, and stakeholder engagement are done accordingly during the project life	Plan scope management • Expert judgment • Meetings Collect requirements • Focus groups • Group decision-making techniques • Document analysis Define scope • Expert judgment • Facilitated workshops Create WBS • Decomposition • Expert judgment Validate scope • Inspection • Group decision-making techniques Control scope • Variance analysis
To create a cost management plan to ensure that a more sustainable cash flow and adequate funds are allocated to the construction	Plan cost management • Expert judgment • Meetings Estimate costs • Expert judgment • Bottom-up estimating Determine budgets • Cost aggregation • Reserve analysis • Expert judgment Control costs • Reserve analysis
To create a schedule management plan to ensure that planning for the metrorail construction is executed within the dedicated timelines	Plan schedule management • Expert judgment Define activities • Decomposition • Rolling wave planning • Expert judgment Sequence activities • Dependency determination Estimate activity durations • Expert judgment • Reserve analysis Develop schedule • Schedule compression

Objectives	Tools
To create a stakeholder management plan to ensure the proper identification, categorization, communication, and participation of program stakeholders	Identify stakeholders • Stakeholder analysis • Expert judgment • Meetings Plan stakeholder management • Expert judgment • Meetings • Analytical techniques Manage stakeholder engagement • Communication methods • Interpersonal skills • Management skills Control stakeholder engagement • Expert judgment • Meetings
To establish a communication management plan to guarantee the timely production, transfer, monitoring, and management of program information to internal and public stakeholders	Plan communication • Communication requirement analysis • Communication methods • Manage communication • Control communication • Expert judgment
To create a sustainable risk management plan that identifies risks and risk responses for risks directly related to the project and those that have sustainability implications	Risk management planning • Risk identification • Qualitative risk analysis • Quantitative risk analysis • Risk response planning • Risk monitoring and control • Expert judgment • Documentation reviews • Information gathering • Techniques • Checklist analysis • Assumption analysis • Diagramming techniques • SWOT analysis
To develop a sustainable procurement plan for identifying and assigning contracts to suppliers who are able to procure sustainable goods and services	• Make-or-Buy analysis • Expert judgment • Market research • Meetings

3.4. Assumptions and Constraints

According to Study Circle (2016), an “assumption is a belief of what you assume to be true in the future” (para. 1), and assumptions are made based on your “knowledge, experience or the information available on hand” (Study Circle, 2016, para. 1); they are anticipated events or circumstances that are expected to happen during your project’s life cycle.

Constraints are defined as “limitations imposed on the project, such as the limitation of cost, schedule, or resources, and you have to work within the boundaries restricted by these constraints…projects have constraints, which are defined at the beginning of the project” (Study Circle, 2016, para. 2).

The PMBOK® Guide (PMI, 2017) identifies six project constraints: scope, quality, schedule, budget, resource, and risk. However, three of these are commonly referred to as the triple constraints: scope, schedule, and budget.

3.4.1. Assumptions

According to Usmani (2020):

> An assumption is what you believe to be true. These are anticipated events or circumstances that are expected during your project’s life cycle. You make assumptions based on your experience or the information available on hand. Assumptions may not end up being true. Sometimes, they can be false, and it may affect your project. This adds risk to the project. (para. 7-8).

3.4.2. Constraints

According to Usmani (2020):

> Constraints are limitations imposed on the project: for example, budget, schedule, or resources, etc. The PMBOK Guide recognizes six project constraints: scope, quality, schedule, budget, resources, and risk. Out of these six, scope, schedule, and budget are known as the triple constraints.

These constraints are defined at the beginning of your project. And you must work within their boundaries.

A constraint can be of two types:

1. Business constraints
2. Technical constraints (para. 17)

3.4.3. Assumptions Vs Constraints

The following are a few differences between assumptions and constraints.

- Assumptions are believed to be true, while constraints are true in nature.
- Assumptions are good for the project, while constraints are not good, most of the time.

If assumptions become false, it is bad news for the project. However, if constraints are false, it is good.

Chart 4. *Assumptions and Constraints*

Objectives	Assumptions	Constraints
To create a sustainable project management plan that integrates planning among the knowledge areas identified by the PMI and outlined in the PMBOK® Guide	A fully integrated project plan will be developed.	Some project phases may not be completed on time.
To create a sustainable scope management plan for the identification of key stakeholders and their unique requirements and expectations	The project scope will be defined.	The scope may change as the project progresses.
To create a sustainable schedule management plan for identifying and decomposing project deliveries into more manageable work packages that can be tracked	A realistic schedule management plan will be developed.	Not enough expert judgment available to provide expert guidance
To create a sustainable cost management plan for assigning costs to work packages and for the determination of the project budget	A detailed budget will be developed.	Not enough time and resources available to complete a detailed budget

Objectives	Assumptions	Constraints
To develop a sustainable quality management plan for outlining the minimum stakeholder acceptance criterion	All stakeholder requirements will be collected and analyzed.	Stakeholders' requirements may change as well as their level of interest.
To create a resource management plan for assigning resources to work packages in a manner that complies with international laws and conventions on labor	All roles and responsibilities will be identified, and someone will be assigned to own those roles and responsibilities.	Some resources may not be available.
To develop a sustainable communication management plan for clearly defining the project communication strategies and line of reporting authority	All lines of command and authority will be documented.	Some communication methods may not be available.
To develop a stakeholder management plan that identifies key stakeholders and their level of interest and analyses how their influence might affect the project	All stakeholder requirements will be identified along with their level of interest.	Stakeholder requirements and level of interest may change during the project.
To create a sustainable risk management plan that identifies risks and risk responses for risks directly related to the project and those that have sustainability implications	All risks will be appropriately budgeted for.	Some risks may occur because of other constraints.
To develop sustainable procurement plan for identifying and assigning contracts to suppliers who can procure sustainable goods and services	All good and services will be procured locally.	Some suppliers may not have the required goods available locally.

3.5. Deliverables

A deliverable is defined as "any unique and verifiable product, result, or capability to perform a service that is required to be produced to complete a process, phase, or project." (PMI, 2017, p. 537). A deliverable is an input/output term that refers specifically to the unique and individual products, elements, results, or items that are produced for delivery at the conclusion of a specific project component, or at the conclusion of the project as a whole. Deliverables can come in several different

variations. Deliverables can be in the form of a written report, which can be extremely lengthy and can encompass extensive amounts of information and data.

Chart 5. *Deliverables*

Objectives	**Deliverables**
To construct a scope management plan to ensure that the requisite cost planning, resource allocation, and stakeholder engagement is done during the project life	**Scope management plan**
To create a resource management plan for assigning resources to work packages in a manner that complies with international laws and conventions on labor	**Resource management plan**
To develop a sustainable quality management plan for outlining the minimum stakeholder acceptance criteria	**Quality management plan**
To create a sustainable risk management plan that identifies risks and responses for the risks directly related to the project and those that have sustainability implications	**Risk management plan**
To develop a sustainable procurement plan for identifying and assigning contracts to suppliers who can procure sustainable goods and services	**Procurement management plan**
To create a cost management plan to ensure that a more sustainable cash flow and adequate funds are allocated to the construction of the metrorail project	**Cost management plan**
To draft a schedule management plan to ensure that planning for the construction is done within the preapproved times	**Schedule management plan**
To create a stakeholder management plan to ensure the proper identification, categorization, and participation of program stakeholders	**Stakeholder management plan**
To establish a communication management plan to guarantee the timely production, transfer, monitoring, and management of program information to all stakeholders	**Communication management plan**

CHAPTER IV. RESULT ANALYSIS

4.1. Project Charter

4.1.1. Develop the Project Charter

The Project Management Institute's *A Guide to the Project Management Body of Knowledge – PMBOK GUIDE® Sixth Edition* (PMI, 2017) states that the project charter may be referred to as a document issued by the project initiator or sponsor that formally authorizes the existence of a project and provides the project manager with the authority to apply organizational resources to project activities. This can be compressed into the following: "The project charter provides the high-level project description, product characteristics, and approval requirements" (PMI, 2017, p. 152).

The advantages of utilizing the project charter include creating a formal record of the project, providing a direct link between the strategic objectives of the organization and the project, and revealing the organization's commitment to the project.

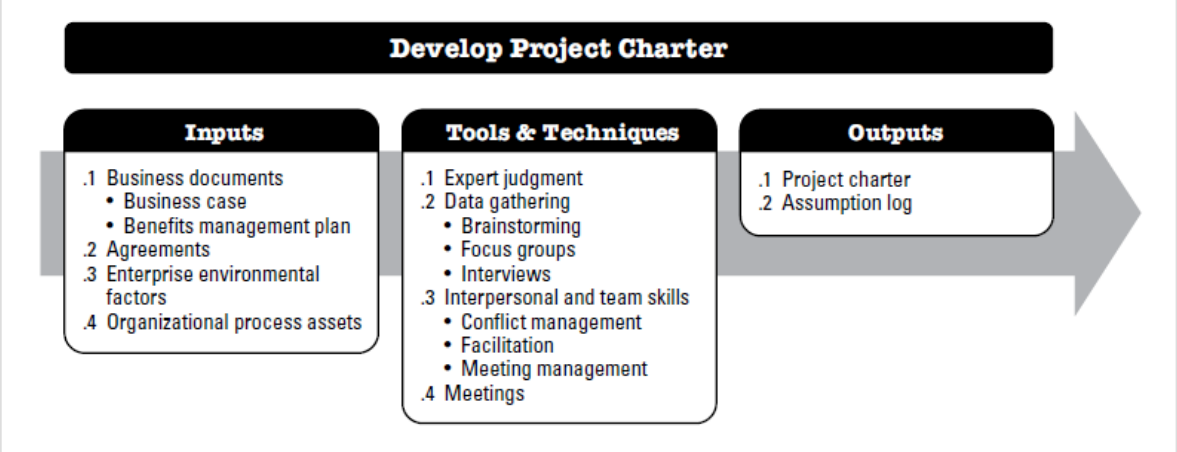


Figure 26. *Develop the Project Charter, Tools and Techniques.*
Source: PMBOK® Guide (PMI, 2017).

4.1.2. Business Documents

The documents are available from various participants of the project: the project manager, director of technology operations, and general manager. The key documents used to plan the way forward were a business case technical paper and

the mobile expansion business case. All documents can also be retrieved from the government domain and Bechtel Corporation domain.

4.1.3. Project Charter

Chart 6. *Project Charter*

PROJECT CHARTER	
Date:	**Project name:**
June 20, 2020	PROJECT MANAGEMENT PLAN FOR THE RAILWAY LINE EXTENSION IN WASHINGTON, D.C.
Knowledge areas / PM processes:	**Application area (sector / activity):**
Knowledge areas: Project integration Project scope Schedule Cost Quality Resources Communication Risks Procurement Stakeholders	Project planning Construction management Communication management Large scale construction Phase level multi city construction
Project start date:	**Project finish date:**
June 20, 2020	January 10, 2021
Project objectives (general and specific):	
PROJECT MANAGEMENT PLAN FOR THE RAILWAY LINE EXTENSION IN WASHINGTON, D.C.	
General objective:	
To develop a project management plan, as per the standards of the Project Management Institute (PMI), that integrates sustainable principles to optimize the utilization of project resources during the construction of the extension of the metrorail to Dulles International Airport and Loudoun County.	
Specific objectives:	
The specific objectives of the project management plan are done in order: 1. To create a sustainable scope management plan that identifies key stakeholders and their specific obligations and opportunities 2. To create a balanced schedule management plan to assign duration to work packages that can be tracked 3. To create a balanced cost management plan to allocate costs to work packages 4. To create a sustainable quality management plan to define the minimum stakeholder acceptance criterion 5. To create a communication management plan to allocate resources to work packages in a manner that is consistent with international law and labor conventions 6. To create a sustainable communication management plan to clearly define the communication strategy of the project and the reporting authorities	

7. To create a sustainable risk management plan that identifies risks and risk responses that are directly related to the project and affect sustainability

8. To create a sustainable order/procurement management plan to identify and assign contracts to suppliers who can obtain sustainable goods and services

9. To create a stakeholder management plan that identifies key stakeholders and their interests and analyzes how their impact can affect the project

Project purpose or justification (merit and expected results):

The purpose of developing a project management plan is to integrate sustainable principles in order to effectively carry out project management activities so that the Dulles metrorail construction can be completed within the planned functional scheduled timeframe, with the desirable quality, and within budget. Just like every other project area, construction projects may fail for several reasons. There is no single method or organizational structure that can be used to manage projects to success. Project failure can happen in any organization and to any project. There is an infinite number of reasons for failure. Sometimes, failure is controllable. To overcome failure for this massive project, the “project management plan” is created.

The goal of project management is to produce a successful construction and not be hindered by the errors of omission as well as commission by management, project managers, team members, and others associated with the projects. The purpose of this project management plan is to enable the identification of the common causes of project failures through the use of surveys to collect information that can be used to mitigate occurrence and in many cases, repair the damage caused and recover the project.

The project management plan is created in order:

a. To create a project management plan that integrates sustainable principles to effectively carry out project management activities
b. To provide planning for an outcome of high-quality and high-capacity transit service in the Dulles Corridor
c. To improve public involvement notices and support the collaboration for local people, business owners, and press meetings
d. To improve internal communication, coordination, and streamline decision-making. Integrate [resources] across all phases of project delivery.

Description of product or service to be generated by the project – project final deliverables:

The final graduation project (FGP) will provide everything necessary regarding a project management plan following the good practices established by the PMBOK 6th Edition. This will include the following: 1. project charter, 2. scope management, 3. scheduled plan, 4. resource management plan, 5. communication management plan, 6. stakeholder management, 7. procurement management plan, and 8. risk management plan.

Assumptions:

An assumption is what you believe to be true. They are anticipated events or circumstances that are expected during your project’s life cycle. You make assumptions based on your experience or the information available on hand.

Assumptions may not end up being true. Sometimes, they can be false, and it may affect your project. This adds risk to the project.

Constraints:

Constraints are limitations imposed on the project: for example, budget, schedule, or resources, etc. The PMBOK Guide (PMI, 2017) recognizes six project constraints: scope, quality, schedule, budget, resources, and risk. Out of these six, scope, schedule, and budget are known as the triple constraints.

These constraints are defined at the beginning of your project. And you must work within their

boundaries.

A constraint can be of two types:
a. Business constraints
b. Technical constraints

Preliminary risks:

1-The cost of the project is expected to go higher depending on the construction phases and environmental factors.
2- There are multiple teams and associated members and stakeholders. The project manager's ability to track the resources and outline the project planning may be delayed considering these factors.
3-The project can be more difficult to execute than expected.
4-This is a large-scale project , and its timeline can be extended depending on its development.

Budget:

The project budget and the established cooperative process total project estimate is $44.5M (org.$56.7M) in phase 1, and the total project estimate is $52M (org. $57M) in phase 2.

Milestones and dates:

Milestone	**Start date**	**End date**
Start of the final graduation project	June 20, 2020	July 25, 2020
Graduation seminar	June 20, 2020	July 25, 2020
Tutoring process	September 5, 2020	January 10, 2021

Relevant historical information:

For the development of the final graduation project, the primary information sources will be considered from several primary approaches that will be used as main sources from the Dulles Corridor Metrorail Project. (n.d.a). Published in December 2004 and the Federal Transit Administration (FTA) Issued Its Record of Decision Approving the Environmental Process in March 2005. Primary sources may also include surveys, interviews, observations, research, historical and legal documents, financial data published in the Dulles metrorail website, accounts, experiment results, statistical data, pieces of creative writing, audio and video recordings, speeches, art objects, Internet searches, fieldwork, and Internet communication via email, blogs, and newsgroups.
Dulles Transit Partners LLC (DTP) selected Bechtel Infrastructure Inc. and Washington Group International (now URS) to construct phase 1 and phase 3 of the 11.6-mile project. DTP is a joint venture. Bechtel has been selected by the Metropolitan Washington Airports Authority (MWAA) to submit a proposal to design and build phase 2 of the Dulles Corridor Metrorail Project. Phase 2 will provide rail service between Washington, D.C. and Washington Dulles International Airport. The Washington Metropolitan Area Transit Authority (WMATA), Fairfax County, Loudoun County, the town of Herndon, and the Metropolitan Washington Airports Authority (MWAA) are partners in this 23-mile transit extension in the rapidly growing Dulles Corridor in Fairfax and Loudoun Counties, Virginia.

Stakeholders:

Federal transit administration of the U.S. Department of Transportation
Local news channels and reports
Environmental activists, NGO's
Project and construction management of the WA Airports Authority
WA railway dept
Airport agency
Transit partner engineering dept
Construction department

Approval:

Project Manager:	Signature: Nikita Saran 
Authorized by:	Signature:

4.2. Scope Management Plan

The scope management plan is an integral part of the project management plan that defines how the scope will be defined, developed, monitored, controlled, and verified. It provides guidance and direction on how the scope will be managed throughout the project.

4.2.1. Approach

Here, scope management will be as provided by the Airports Authority with regular reviews of DTP's design documents and diligent monitoring of potential deviations to the design basis. Technical control will be achieved through Airports Authority review of the designs as they are as well as of system performance specifications to assess DTP's compliance with the design criteria, standards, and basis of the design report.

This scope management plan will ensure that the project includes all tasks required to complete the Dulles Metropolitan Corridor Project and detail how the scope will be defined, validated, and controlled as indicated in the PMBOK® Guide. The scope management plan was created using a template taken from an online source and prepared using the input received from the project charter, meetings, data analysis, and expert judgment. It includes the scope definition, project scope

statement, the work breakdown structure (WBS), WBS dictionary, scope verification, and the scope control measures to be used as guidance by the project management team throughout the project.

4.2.2. Roles and Responsibilities

The various roles in managing the scope of the project are handled by the project manager, sponsor, and project team. To guarantee that the project scope is enacted alongside the established protocols, the roles and responsibilities are to be defined and communicated. Figure 27. identifies key stakeholders, their roles, and responsibilities. The project manager, sponsor, and project team will play different roles in managing the scope of the project. To ensure that the project scope is performed as established, the roles and responsibilities are to be defined and communicated. Figure 27. below identifies the key stakeholders and their roles and responsibilities towards the scope management plan of this project.

			1	2	3	27	28	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46
			Administrative Interface between Project Office and Airports Authority's Headquarters Staff	Agency Coordination	Arts in Transit Program Management	Airports Authority QA Policy & System Compliance	Airports Authority Safety & Security Policy Compliance	Before and After Study	Budget Adherence	Capital Funding Program Management (FFGA)	Communications Management	Community Outreach Management	Construction Management	Construction QA	Construction Safety	Contract Compliance	Contract Modifications Negotiations	Contractor Invoices & Procedures Management	Design Management	Dispute Resolution	Document Control	DTP QA/QC Plan and Procedures	DTP System Safety/Security Certification Management Program	Environmental Planning	Final Design Grant Agreement Compliance	Financial Plan Adherence; Monitor Cash Flow	FTA Requirements Compliance (Beyond NEPA)	Grant Administration	Cooperative Agreement Execution & Implementation	Marketing Management	NEPA Compliance (Mitigation Monitoring)	New Starts Program Support	Office Administration	Owner Permits	PMP Updates	Project Contingency Management	Project Controls	Property Inventory Maintenance	Regulatory Compliance	Reporting	Risk Management	ROW Acquisition	Schedule Adherence	Start-Up Testing	Technical Inspection	TMP Coordination	Utility Relocation Work	Variance Processing
			1	2	3	27	28	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46
Airports Authority	Executive Project Director (4th Quarter 2008)	1	X	X					X				X				X		X	X							X		X																		
	Project Director (S. Carnaggio)	2	X	X		X			X	X	X	X	X				X	X	X	X					X	X	X	X	X			X			X	X			X	X	X					
	DD of Project Development (J. Van Zee)	3		X				X	X									X						X			X		X			X				X			X		X	X			X	
	DD of Design (N. Hsu)	4		X	X		X		X							X	X	X	X						X		X		X			X			X	X		X	X	X		X			X	X
	DD of Construction (K. Volbrecht)	5		X		X	X		X				X	X	X	X	X	X		X						X		X		X			X		X	X	X		X	X	X		X	X	X	
	DD Project Finance (J. Mitchell)	6		X					X	X						X		X							X	X	X	X			X								X						
	Manager of QA/QC & Safety (J. Christensen)	7				X	X							X	X			X			X	X	X				X												X							
	Manager of Project Administration (4th Quarter 2008)	8	X	X					X		X							X			X					X						X	X	X	X					X						
	QA/QC Supervisor (T. Bell)	9				X								X								X																									
	Safety Supervisor (R. Gillwald)	10					X								X								X																								
	Contracting Officer (R. Carey)	11	X						X							X	X										X																				
	Contract Administration Officer (W. Thiel)	12							X							X	X										X	X	X							X				X						
	Manager of Risk Management/Project Controls (G. Daniel)	13							X							X	X			X						X	X		X							X	X		X	X	X		X				X
	Manager, Rail Communications (M. McAllister)	14			X						X	X																		X																	
	Senior Project Manager, Construction (4th Quarter 2008)	15		X		X	X		X				X	X	X	X	X	X		X						X		X		X			X	X	X	X	X		X	X	X		X	X	X	
	Senior Project Manager, Design (Alan Kolodne)	16		X	X		X		X							X	X	X	X	X					X		X		X			X		X	X	X		X	X	X		X		X	X	X
PMSS	Project Manager (S. Sabo)	17		X			X		X	X			X	X	X	X	X	X	X	X	X			X		X						X			X	X	X			X	X	X		X		X
	QA Specialist (S. Hinkle)	18				X								X								X					X																			
	Diversity Officer (T. Davis)	19														X											X																			
	Deputy Project Manager (J. Cramer)	20		X					X							X	X	X		X									X							X				X	X	X				
	Community Relations Support (Commonwealth Consultants/APCO)	21									X	X																		X																
	Project Controls Manager (W. Cromarty)	22							X	X						X	X	X		X						X	X								X	X				X	X		X			X
	Planning Oversight Manager (L. Miller)	23						X	X	X														X	X	X	X	X			X	X			X		X	X	X	X		X		X		X
	Design & Engineering Oversight Manager (C. Roberts)	24		X	X				X								X		X										X										X	X		X		X		X
	Construction Oversight Manager (B. Whedon)	25		X			X		X				X	X			X					X							X				X						X	X		X	X			X	
	Construction Oversight Deputy Manager (J. Kearney)	26		X			X		X				X	X								X												X					X	X			X			X	
	Systems Oversight Manager (P. Castellana)	27		X					X				X	X			X		X				X															X				X	X	X			X
	Real Estate Acquisition Manager (P. Peckham)	28							X																		X									X			X		X					
	Project Administration & Program Logistics (D. Olguin)	29																			X											X															
	Environmental Compliance (D. Clark)	30		X																				X			X				X							X									

Figure 27. *Stakeholders, Roles and Responsibilities*
Source: Dulles Metro Corridor Project (n.d.c).

4.2.3. Project Scope Statement

The PMP is a dynamic document that will be reviewed annually and updated as required. To date, the FTA has accepted five versions of the PMP for this project reflecting previous stages of the project development sponsor and the Airports Authority, rather than the Commonwealth of Virginia (the Commonwealth). It is responsible for the management of the final design and construction of the project, and it is focused on final design activities following the FTA's approval to enter the final design.

The scope for the Dulles Metropolitan Corridor Project includes the follwing:

- An adequate grant recipient staff organization, complete with well-defined reporting relationships, a statement of functional relationships, job descriptions, and job qualifications
- The project management organization and management structure necessary to complete the final design and construction
- A plan covering the project management organization and final design and construction activities
- An implementation plan for the entire project, including the design and construction stages
- A document control procedure and record-keeping system
- The Airports Authority should have a comprehensive understanding of the project requirements, ranging from compliance with environmental and code requirements to WMATA design criteria and Virginia PPTA guidelines.

4.2.4. Project Exclusions

The project management plans, including the Airports Authority quality program plan and the Airports Authority safety and security management plan (SSMP).

The PMP provides more specific information; however, in this project management plan, we will not be addressing the following areas:

- Labor relations and policy
- Risk assessment

- Environmental analysis and mitigation
- Design program
- Real estate acquisition
- Community relations
- Construction management
- Intergovernmental and utility agreements
- Conflict resolution
- Planning for operation start-up
- General joint development program supplementing

4.2.5. Project Constraints

These plans, described in further detail in the PMP, respectively provide additional guidance and requirements related to QA/QC and safety and security that are to be applied during the course of the project to ensure that quality, safety, and security objectives are achieved and that related requirements are met.

Third party (utility) restrictions and constraints on performing to the required level of effort to complete cable installations in conjunction with the project scope. Partnering is a long-term commitment between two or more organizations to achieve specific objectives by maximizing the effectiveness and cooperation of each participant's resources. Partnering often requires changing traditional management relationships to a shared culture without regard to organizational boundaries. The relationship is based on trust, dedication to common goals, and an understanding of each other's individual constraints, expectations, and values.

4.2.6. Project Assumptions

It is assumed that the project scope has been correctly identified and no additional modifications are needed.

4.2.7. Acceptance Criteria

Project success is "the intended result of a project and what is required to bring it to completion. To get a real measure of your project's success you want to

determine if it achieved its objectives within the given framework" (Eskander, 2018, para. 1).

Success will be determined by the following elements:

- WMATA has been involved with the project from the start of the PE/NEPA stage through the pre-final design stage.
- WMATA's involvement will not change in the stages yet to come, which include final design, construction, safety certification, and pre-revenue start-up.
- WMATA will provide staff support as a technical advisor to the Airports Authority and will assist with design reviews, testing, and start-up acceptance.
- WMATA will manage the interface with the existing WMATA system in accordance with schedule requirements established in the master project baseline schedule.

4.2.8. Work Breakdown Structure

This section contains the work breakdown structure (WBS) and its related information. The WBS and WBS dictionary are important components of effective scope management. The WBS for the Corridor project provides the hierarchical decomposition of the total scope of work to be carried out in fulfillment of the objectives of the project. Decomposition techniques were applied in this process with the assistance of the project designer, who has vast experience in this type of projects and who was responsible for the previous project performed in the same area.

The Corridor construction activities were subdivided into individual work packages to allow the project manager to manage the project's scope more effectively as the project team works on the tasks necessary for project completion. Project scope requirements were included in the WBS as shown in Figure 28 below.

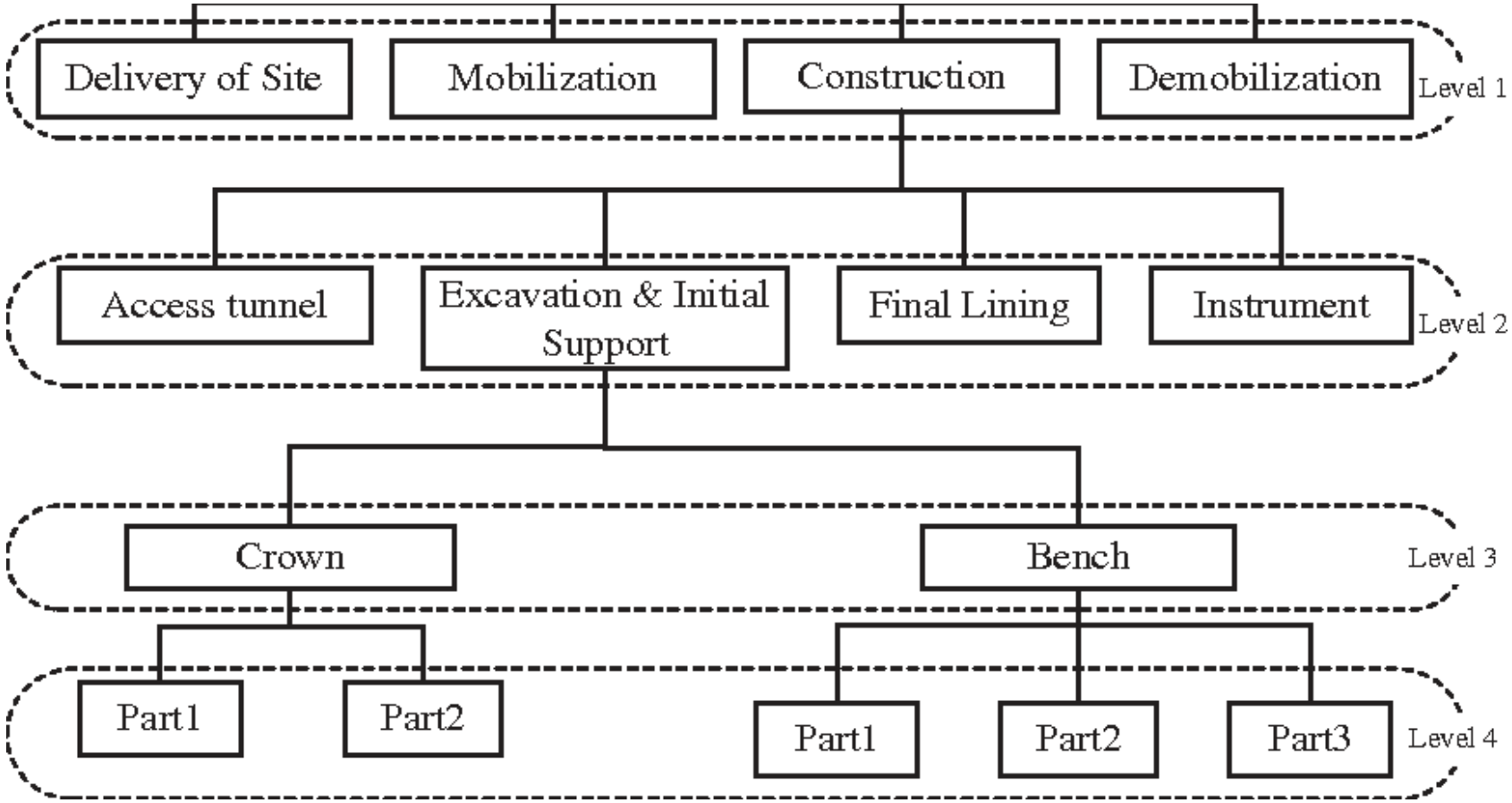


Figure 28. *Project scope requirements.*
Source: Dulles Metrorail Project (n.d.a).

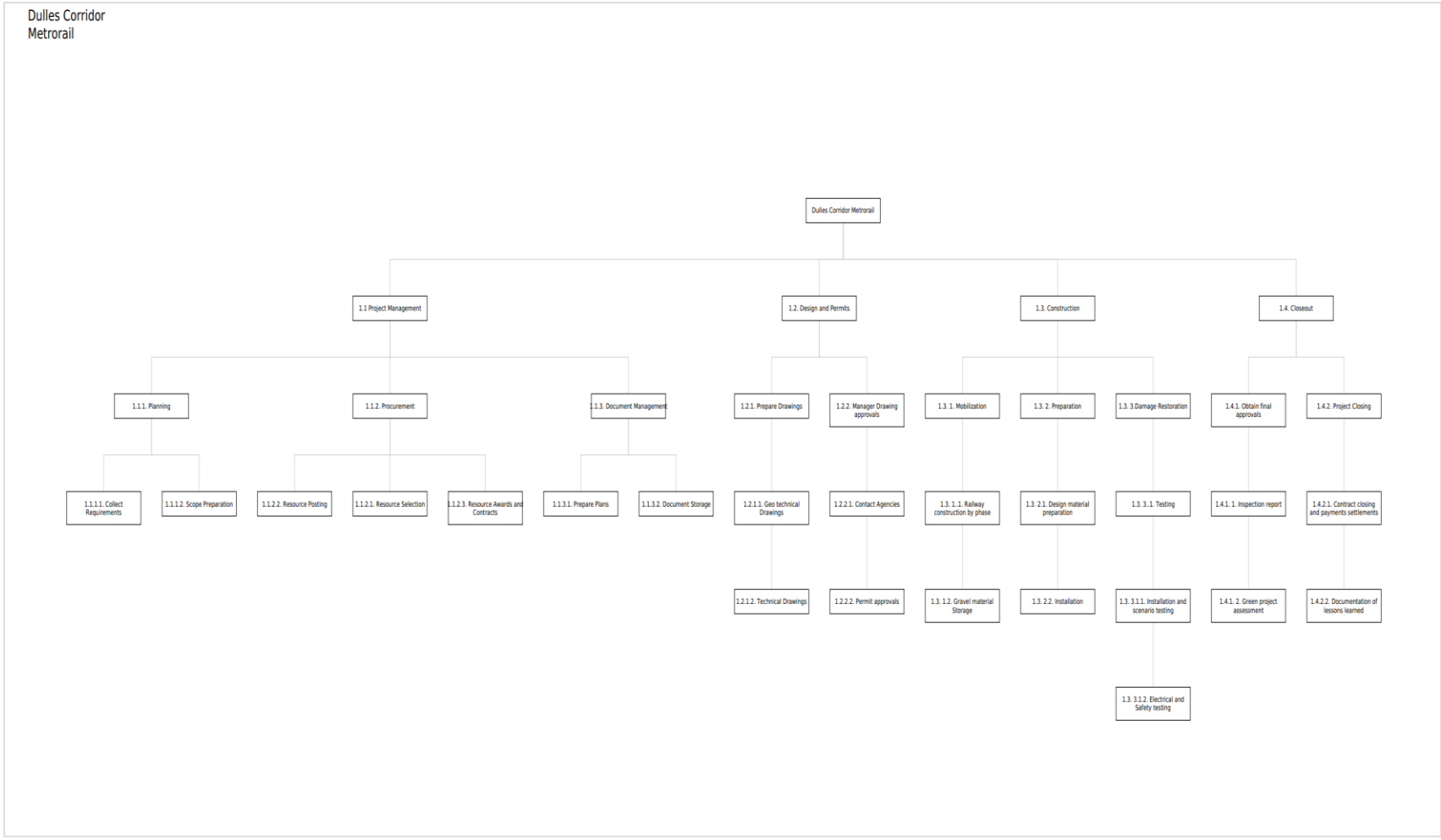


Figure 29. *Work Breakdown Structure.*

To define the work necessary for project completion more clearly, the WBS dictionary is used. The WBS dictionary includes an entry for each WBS element. The WBS dictionary includes a detailed description of work for each element and the general deliverables (see chart 6).

Chart 7. *WBS Dictionary*

Level	***WBS code***	***Element name***	***WBS description***
1	1.1	Project management	Commencement of the project planning phase and decision making
	1.1.1	Project planning	Gathering all information and requirements for planning purposes
	1.1.1.1	Collect requirements	Meetings held to determine project requirements
	1.1.1.2	Scope preparation	Analysis of obtained information
	1.1.2	Procurement	Contract/award processes
	1.1.2.1	Resource selection	Selecting needed resources as project support
	1.1.2.2.	Resource posting job requirements	Posting project resource job requirements
	1.1.2.3	Resource awards and contracts	Selecting suppliers and a construction contractor firm
	1.1.3	Document management	Hardcopy and electronic file preparation
	1.1.3.1.	Prepare plans	Project specific design and the corresponding permitting process for construction
	1.1.3.2.	Store documents	Reviewing and approving certified drawings and specifications provided by the designer and storing them for the necessary departments to access
2	1.2	Design and permits	
	1.2.1	Prepare drawings	Managing the permitting strategy and preparing and submitting all permitting documentation
	1.2.1.1.	Geo technical drawings	Collecting geo or non-technical drawings
	1.2.1.2.	Technical drawings	Technical drawings are important to be submitted to the corresponding departments.
	1.2.2.	Drawing approval manager	Meeting with regulatory agencies to define the permitting strategy and/or clarifying doubts and fetching appropriate manager approvals
	1.2.2.1	Contact relevant agencies	Follow up process to obtain the permit approval as scheduled
	1.2.2.2	Permit approvals	Keeping the relevant approvals from all related agencies up to date
	1.3.	Construction	

Level	*WBS code*	*Element name*	*WBS description*
	1.3.1.	Mobilization	Contractors' equipment and temporary office storage/location in the project area
	1.3.1.1.	Railway construction by phase preparation	Earth crust preparation/movement as identified in grading
	1.3.1.2.	Gravel material storage	There are several measures/conditions to be installed as pre-construction requirements.
	1.3.2.	Preparation	Corridor construction preparation
	1.3.2.1.	Design material preparation	Control measures are to be installed as per design.
	1.3.2.2.	Corridor installation	Safety measures are to be installed as per design.
	1.3.3	Damage restoration	Corridor damage restoration as per design
	1.3.3.1	Testing	Corridor installation pretesting before deployment to production
	1.3.3.2.	Installation and scenario testing	Installation pretesting before deployment to production
	1.3.3.1.2	Restoration of rock vane 5	Rock vane 5 restoration as per design
	1.3.3.1.3	Electrical and safety testing	Electrical and user safety pretesting before deployment to production
	1.3.3.1.4	Site stabilization and material removal	Site stabilization and material removal
	1.4	Closeout	Contracts closing, payments performed, and final documentation approved
	1.4.1	Final approvals	Final documentation approved
	1.4.1.1	Inspection report	The inspector will validate in the field that all construction works were completed and certify it in a report.
	1.4.1.2	Green project assessment	Checking the conditions meeting green project management
	1.4.2	Project closing	The closing of contracts and invoice payment
	1.4.2.1	Contracts' closing	Ensuring all contracts are closed
	1.4.2.2	Documentation of the lessons learned	Meeting and gathering lessons learned from the project execution

4.2.9. Scope Change

Any project team member can leverage the project scope template to make or request any changes, submit the completed change request form (see Chart 7), and submit it to the project manager for his evaluation.

For this project, the possibilities of change request approvals related to the project scope are very limited due to the time and budget constraints. Change requests must be justified only if they are critical activities affecting safety or compliance in the project. If the change request is approved by the project manager, he will present it to the project sponsor to obtain the final approval. Once granted, the PM will communicate the scope change to the stakeholders and update all related documents. A change request form template with the recommended queries is included as Chart 7.

Chart 8. *Change Request Form Template*

Change request form	
Project: Dulles Corridor Metro Rail	Date:
Change requestor:	Change No:
Requestor department:	
Financial impact	Yes/No
Change category (check all that apply): □ **Schedule** □ **Cost** □ **Scope** □ **Requirements/Deliverables** □ **Testing/Quality** □ **Resources**	
Does this change affect (check all applicable): □ **Corrective action** □ **Preventative action** □ **Defect repair** □ **Updates** □ **Other**	
Describe the change being requested:	
Describe the reason for the change:	
Describe all alternatives considered:	
Describe any technical changes required to implement this change:	
Describe risks to be considered for this change:	

Estimate resources and costs needed to implement this change:
Describe the implications to quality:
Disposition: **□ Approve □ Reject □ Defer**
Justification of approval, rejection, or deferral:

Approval:		
Name	Signature	Date
Project manager		
Sponsor		

4.2.9.1. Scope Control

The project manager will be controlling the scope of work through inspections and continuous status meetings (at least once a week).

The team will perform the work reflected on the WBS and WBS dictionary. The project manager will review weekly progress reports to ensure project works are progressing as planned.

Project scope measurement tools will be used as part of the variance analysis process to ascertain project compliance and matters that need addressing.

4.2.9.2 Scope Verification

In this section, deliverables will be verified for formal acceptance through a series of periodic scheduled meetings between the project manager, inspector, sponsor, designer, and other team members.

During that interaction, group decision-making techniques will be utilized at every inspection of project deliverables throughout the life of the project. As the project progresses, the project manager will verify project deliverables against the original scope. The project manager will grant provisional acceptance to individual deliverables submitted for review once each is satisfactorily attempted. The project

manager then engages in subsequent deliberations with the project sponsor who ultimately provides the formal acceptance for each deliverable. Once approved, the project sponsor and project manager sign the project deliverable acceptance document (see Chart 9). Items that do not meet the specifications are returned to the team to be addressed and reported back to the project manager. The quality management plan provides thresholds and complementary information to be used in the acceptance process and documented in the project deliverable acceptance form.

Chart 9. *Project Deliverable Acceptance*

Project title:	**Dulles Corridor Metrorail Project**
Deliverable name	Description of the deliverable to be accepted
Acceptance criteria	Provide the criteria against which the deliverable will be set (refer to the quality management plan for details)
Verification method	
Validation method	
Client name	
Client signature	
Signature date	YYYY-MM-DD

4.2.9.3. Plan Approval

This scope management plan has been reviewed and approved by the members of Chart 10.

Chart 10. *Scope management plan members*

Approver name	**Title**	**Signature**	**Date**
Dheemanth SR	Project Sponsor		
Nikita Saran	Project Manager		

Revision History			
Version	**Date**	**Reason**	**Executive sponsor sign off**

4.3. Schedule Management Plan

The PMBOK Guide 6th Edition (PMI, 2017) describes the schedule management plan as “the process of establishing the policies, procedures, and documentation for planning, developing, managing, executing, and controlling the project Schedule” (PMI, 2017, p. 173) . “The key benefit of this process is that it provides guidance and direction on how the project schedule is managed throughout the project. This process is performed once or at predefined points in the project" (PMI, 2017, p. 156).

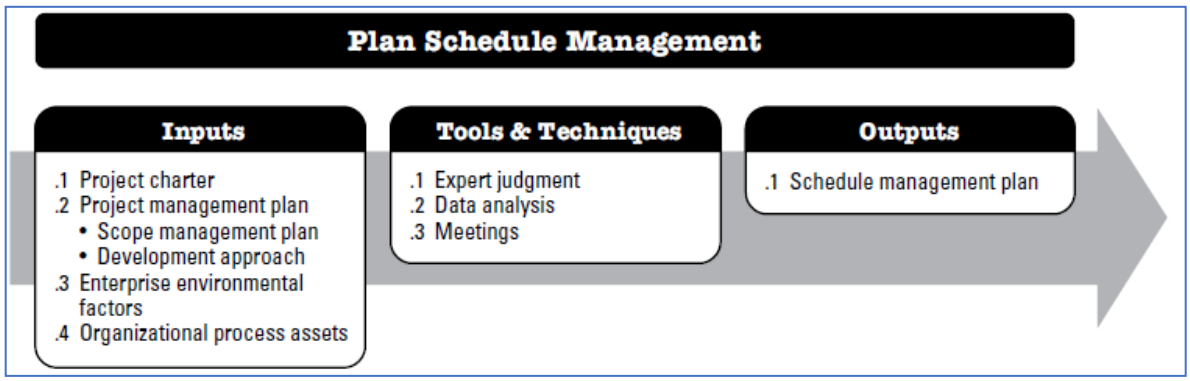


Figure 30. *Plan Schedule Management: Inputs, Tools & Techniques, and Outputs. Source: PMBOK® Guide (PMI, 2017).*

4.3.1. Introduction

The project schedule has been prepared in stages during the development of the project. An initial baseline schedule was prepared and attached to the design-build contract with DTP. Subsequently, schedules by WMATA, VDOT, and the Airports Authority were attached to the logic in the initial baseline schedule to form the initial project master schedule.

4.3.2. Schedule Management Approach

The purpose of this schedule was to guide and prioritize the project activities during the development of the final baseline master schedule, particularly about the criticality of activities. The proposed final baseline schedule contains more than 10,000 activities and addresses every aspect of the project, including design, design approvals, property acquisition, utility relocations, material procurement, equipment and subcontracts, fabrication, installation, and commissioning and testing through the final completion and revenue operations. It is anticipated that additional details will be included as part of the ongoing planning process, particularly with regard to the input from the allowance item subcontracts and final start-up and commissioning planning with WMATA.

Various levels of schedules will be produced for the project. They range from a level 1 summary schedule for use in the public involvement program to a detailed level 3 critical path schedule for project management and control purposes.

The schedule management plan serves to establish the benchmark and procedures for developing, monitoring, and controlling the project schedule. The change management protocols are the only way for a change request to be considered. The project manager has the overall responsibility for schedule management.

4.3.3. Roles and Responsibilities

The roles and responsibilities for schedule development are below:

Chart 11. *Roles and Responsibilities.*

Roles/Names	Responsibilities
Project manager	The project manager is responsible for work facilitation, package definition and sequencing, estimation duration, and resource assignment with and within the project team.
Project sponsor	Along with the PM and project team members, the project sponsor verifies the schedule. He also participates in schedule reviews and grants the final schedule approval before being baselined.
Project team members	They are responsible for the preparation of all required documentation that accompanies the schedule management. Also, they are active critics in the review process of the ongoing schedule.
Project scheduler	The project scheduler creates the project schedule using MS Project. The project scheduler, project team, project manager, project sponsors, stakeholders, and contractors come together to validate the schedule.
Contractors: riggers, installers, and IT specialists	They are responsible for performing their assigned duties in conformance with the schedule.
Betchel Corporation's network designers	They are responsible for the network design in accordance with local and international telecommunication regulations within the specified time to attain the requisite approvals.
Government ministries/local regulatory agencies	They approve permits/requests in a timely manner.

4.3.4. Scheduling Method

The project is being executed through a design-build approach, which offers a number of cost and schedule advantages over a traditional design-bid-build approach. The design-build approach is described in this section as indicated in the PMP.

The scheduling method used for this project is the critical path method. It is defined as a resource-utilization algorithm for scheduling a set of project activities. It requires the construction of a project model that includes the following:

- A list of all tasks required to complete the project
- The dependencies between the tasks
- The estimate of time (duration) that each activity will take to complete

The critical path is then determined by identifying the longest stretch of dependent activities and measuring them from start to finish.

4.3.5. The Scheduling Process

Project schedules will be created using the latest version of MS Project Online using office365, starting with the deliverables identified in the project's work breakdown structure (WBS). Activity definition will identify the specific work packages, which must be performed to complete each deliverable. Activity sequencing is used to determine the order of work packages and assign relationships between project activities.

Activity duration estimating is used to calculate the number of work periods required to complete work packages. Through resource estimating, the assignment of resources to the corresponding work packages is performed. The establishment of the project schedule involves analyzing activity sequences, resource requisites, and schedule durations and constraints. Once the schedule is developed, the project's sponsor will approve it, and it will then be baselined. Only the scheduler and the project manager will have access to edit the schedule.

Activity resources were estimated using information from previous projects and with the input obtained from the expert judgment of the scheduler, project manager, and other team members.

4.3.5.1. Activity, Schedule, and Resource Chart

Chart 12. *Activity Chart*

WBS	Milestone	Date	Predecessor	Successor
1	Initiate	June 20, 2020	NA	2
2	Complete	June 30, 2020	1	3
3	Submit the request to enter the final design.	June 30, 2020	2	4
4	Amended ROD (record of decision)	July 1, 2020	3	5,11
5	Airports Authority certified as FTA grantee	July 5, 2020	4	11
6	Signed master transfer agreement, Dulles toll road permit, and operating agreement	July 15, 2020	11	7
7	Signed design-build contract	July 30, 2020	8	9,13
8	Executed assignment and assumption agreement	July 20, 2020	6	7
9	Signed Airports Authority/Fairfax County cooperative agreement	Aug, 1, 2020	7	10
10	Signed Airports Authority/VDOT cooperative agreement	Aug 5, 2020	9	14
11	Signed project funding agreement	July 5, 2020	5	6
12	Signed Airports Authority/WMATA cooperative agreement	July 10, 2020	5	8
13	Submitted final design application	Aug, 1, 2020	9	14
14	Final design approved by the FTA	Aug 30, 2020	10	15
15	Submit FFGA application	Aug 30, 2020	14	16
16	Execute FFGA	Sept 1, 2020	15	17
17	Begin construction	Sept 1, 2020	16	18
18	Start-Up/Testing	Oct 25, 2020	17	19
19	Safety and security certification	December 20, 2020	18	20
20	Pre-Revenue operations	December 22, 2020	19	21
21	Target revenue service	January 2, 2021	20	22
22	FFGA close-out activities	January 5, 2021	21	23
23	Revenue operation date	January 10, 2021	22	NA

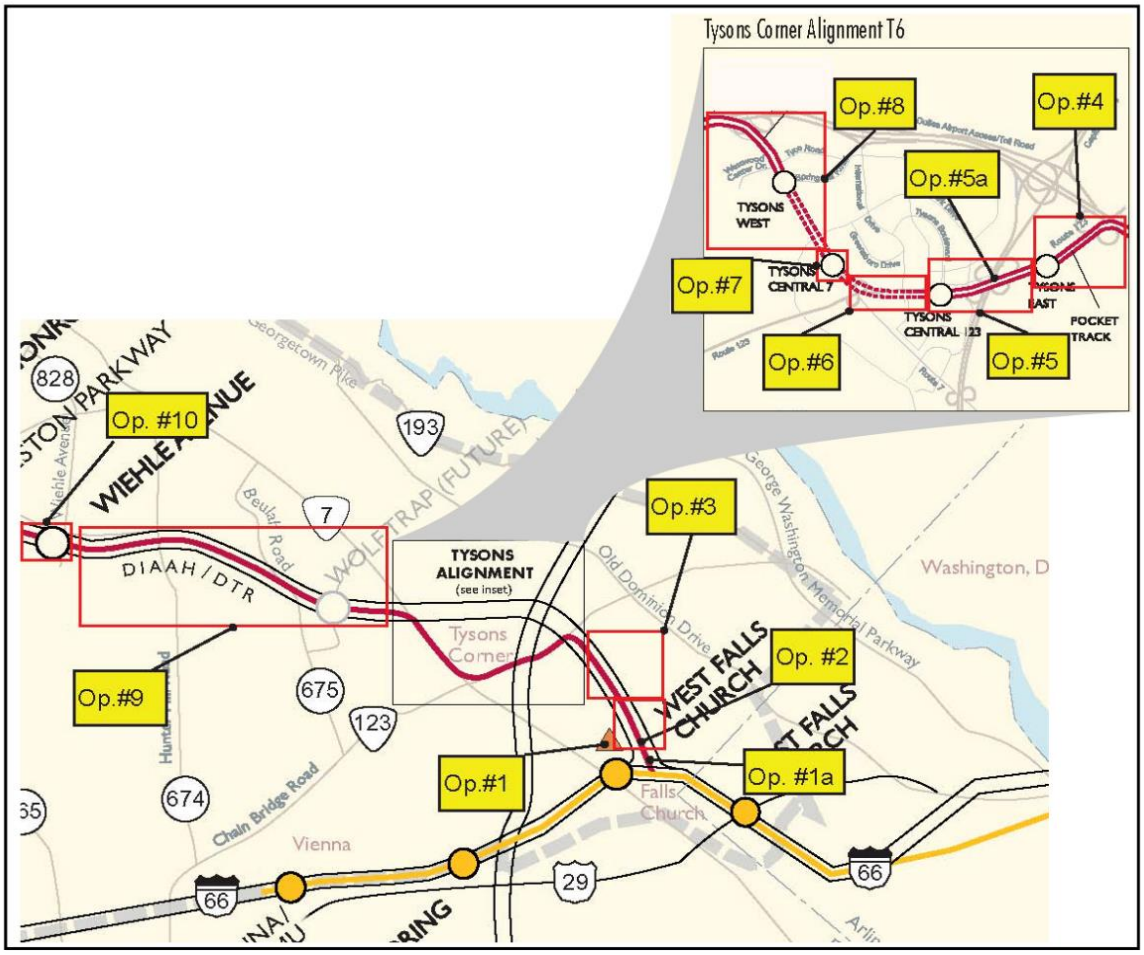


Figure 31. *Schedule Operational Areas,.*
Source: Dulles Corridor Project (n.d.c).

4.3.5.2. Schedule Operational Model

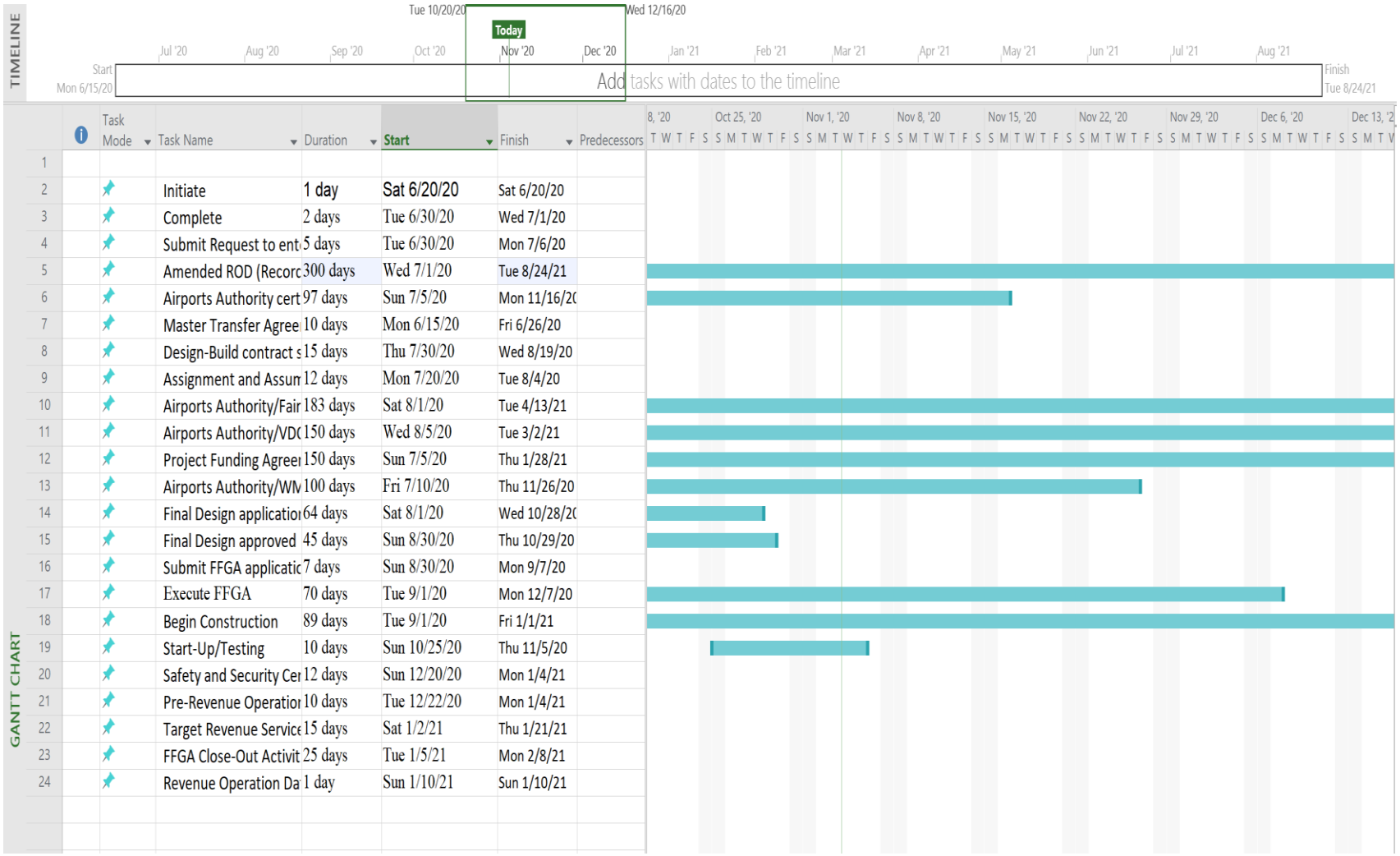
Given the project's design-build approach, it is normal and desirable that construction will commence before the final design is complete. Utility relocations are considered the front-end portion of the construction work. The utility relocations design is essentially complete, and the field work of utility relocations has begun in accordance with the FTA's approval to proceed with the final design and utility relocations. Although included in the design-build schedule, the cost of the utility relocations work is not part of the firm fixed price component of the design-build contract. The utility relocations work is being executed under a cost reimbursable/time and materials agreement. All interfacing points between utility

relocations and the design-build construction are defined in the baseline master schedule.

Chart 13. *Schedule Operational Model*

Operational area		Completion date	
1	Description	Final design	Construction
2	West Falls Church Yard	Aug 30, 2020	Sept 1, 2020
3	K-Line tie-in	Sept 10, 2020	Sept 10, 2020
4	Dulles connector road, cut & cover tunnel (I-66 crossing)	Sept 15, 2020	Sept 15, 2020
5	At-Grade trackwork, bridge crossings	Sept 20, 2020	Sept 20, 2020
Route 123			
7	Aerial guideway, Tysons East Station	Oct 1, 2020	Oct 1, 2020
8	Aerial guideway, Tysons Central 123 Station	Oct 15, 2020	Oct 15, 2020
9	I-495 crossing	Oct 15, 2020	Oct 15, 2020
10	New Austrian tunneling method (NATM) tunnel, tunnel, and east vent structure	Oct 20, 2020	Oct 20, 2020
Route 7 - balance of utilities and roadway			
12	Tysons Central 7 Station, cut & cover tunnel, west vent	Nov 10, 2020	Nov 10, 2020
13	Aerial guideway, Tysons West segment	December 10, 2020	December 10, 2020
DIAAH			
15	At-Grade trackwork, bridge crossings	December 20, 2020	December 20, 2020
16	At-Grade trackwork, Wiehle Avenue Station and parking garage	December 22, 2020	December 22, 2020
17	System-Wide	December 31, 2020	January 3, 2021

4.3.5.3. Gantt Chart, Project Baseline, and Critical Path



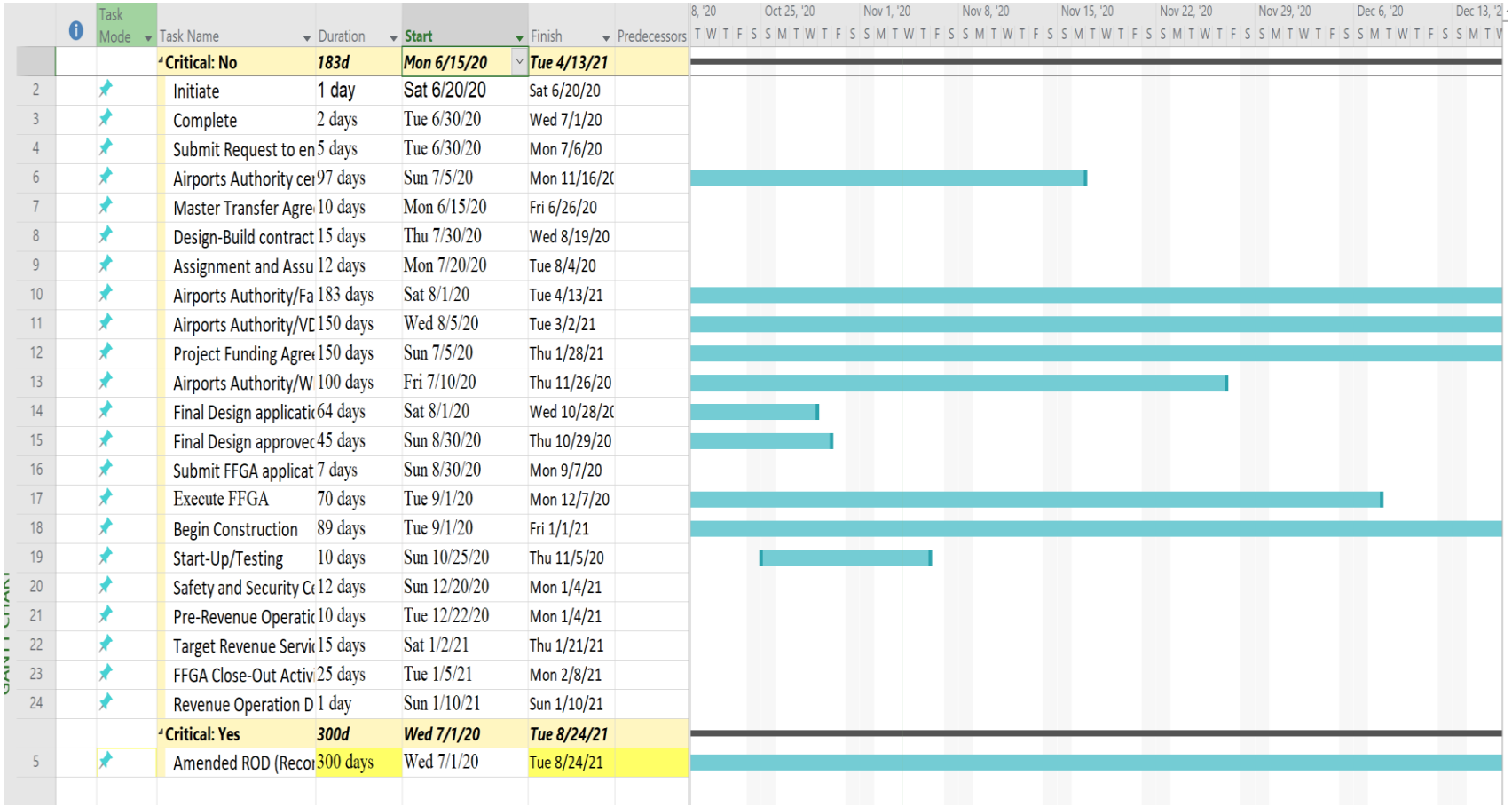


Figure 32. *Gantt Chart.*

4.3.5.4. Schedule Changes

During the Dulles Corridor Project, a change to the schedule is considered necessary. The change will be logged through the change management process. The project manager, project sponsor, and relevant subject matter experts will examine the recommended change and determine whether it has merit and approve it. Once the change proposal is ratified, the project manager ensures that the schedule is adjusted and the changes recorded and then communicated to all necessary stakeholders. The project manager must determine if the change is acceptable. Once the change request has been reviewed and approved, the project manager will ensure that the schedule is adjusted and changes are communicated and recorded.

4.3.5.5. Reporting on the Project Schedule

The project manager and the project team review the project schedule weekly. The actual project status is compared to the project baseline and the calculated schedule variance. The schedule control process involves regular data gathering on project performance, compared with the planned performance. The program team uses the following:

- Progress reporting: reports detailing the actual start and finish dates of the activities
- The schedule variance is an indicator of whether the project is ahead, at, or behind schedule.

For this project, variations in schedule shall be monitored and controlled consistently to ensure that identified critical path activities (permitting process) do not affect construction execution outside the limiting period identified through January 5. Any variation affecting the critical path activities is to be defined and discussed to find and implement the appropriate corrective measures to avoid project delays.

All risks related to the schedule are documented in the risk management plan. They are continuously scrutinized and regularly updated to avoid potential project delays.

4.3.5.6. Risks

While planning and managing the project schedule, risks may be identified. All risks regarding the project schedule are documented in the risk management plan and shall be analyzed, evaluated, and updated frequently to avoid project delays.

4.3.5.7. Schedule Management Plan Approval

This schedule management plan has been reviewed and approved by the members of Chart 14.

Chart 14. *schedule management plan members*

Approver name	**Title**	**Signature**	**Date**
Dheemanth Rajakumar Final approver	Project Sponsor		
Nikita Saran	Project Manager		

Revision History			
Version	**Date**	**Reason**	**Executive sponsor sign off**

4.3.5.8. Schedule Control

Responsibility for planning and scheduling the project, as well as for executing the project in accordance with the plan, is shared among all project participants. Each participating organization submits both its original baseline schedule and

monthly updates of its schedule to the Airports Authority, who collects the information and assembles it into the master project schedule.

The Airports Authority maintains oversight of the entire project plan and controls the content and quality of the schedule, without interfering with the means and methods of the contributing participants, through the language in the respective contracts and agreements as well as in the project's specifications. The Airports Authority meets monthly with DTP to review its contribution to the master project schedule. In these meetings, progress and changes are fully discussed. Progress discussions also include information sharing on schedule performance, delays during the period, issues affecting schedule, and critical and sub-critical paths. WMATA and other contributing organizations are also invited to attend this meeting. Should these discussions result in changes to the schedule, the changes are incorporated and the schedule is reissued within 10 days of the meeting.

The master project schedule's activities are not cost or resource loaded, as there is no requirement for earned value management systems. However, to effectively produce cash flow and cost performance information, the schedule's activity dates are downloaded into PRISM, the cost management system, for cash flow and status measurement purposes. Once the (cost) control accounts have been assigned both early and late schedule activity dates and expenditure curves, PRISM will calculate both early and late expenditure profiles for that control account.

The PRISM system then applies the actual costs recorded for both period and cumulative and presents this information on the cost profile to demonstrate expenditure performance in relation to time. It should be noted that the Airports Authority has negotiated payment schedules that are tied to DTP's detailed earned value systems for both design and construction progress measurement. Schedule reviews and updates will be conducted on a monthly and as-needed basis to ensure adherence to the schedule requirements.

Any schedule changes are to be analyzed to model "what-if" scenarios to evaluate potential delays or to develop workaround solutions. The schedule reviews will be performed according to the Airports Authority's established procedure for the review of project schedules (project management procedure 5.03).

4.4. Cost Management Plan

4.4.1. Introduction

The cost management plan defines the way the costs associated with the Dulles Corridor project are managed. The plan follows the recommendations of the PMBOK® (PMI, 2017) with regards to planning, managing, and controlling costs.

4.4.2. Cost Approach

The project cost will be managed using the PMBOK (PMI, 2017) methodologies. As described, the system provides the ability to integrate the schedule information with cost information for the purpose of developing and maintaining cash flows.

As part of project management, financial accounting, resource management, and reporting, the system will provide the ability to manage all aspects of project cost information, including budgets, actual costs, and estimates at completion. Costs are assigned to control accounts, which are further broken down into cost elements. The control accounts are coded with the SCC codes that are identical to the ones that are embedded in the project schedule's WBS coding. Cost elements include such breakdowns as direct labor, subcontracts, permanent materials, other indirects, and construction equipment.

It should be noted that this coding includes the separation of federal versus non-federal costs for cost reporting segregation. The control accounts and cost elements have been established to mirror DTP's and WMATA's schedule of values for an efficient and seamless input and update of monthly cost data. Budgets are established, approved, and entered into the PRISM enterprise cost system. As change orders are approved, as described in the project management procedure, the baseline or original budgets will be supplemented, creating the current budgets. Scope control is strictly maintained throughout the project, as it is not the current plan to process cost trends and estimate at completion deviations from the budget as it changes. Changes are funded from (or contribute to) the contingency in accordance with the project management procedure.

4.4.3. Roles and Responsibilities

To complete this project successfully, all key project members and stakeholders must adhere to and work within this cost management plan and the overall project plan it supports. The roles and responsibilities towards the cost management plan are included in the table below.

Please note that this project consists of numerous contractors and vendors; hence, we will use common terms as Dulles Corridor contractors for the vertical budgeting.

Chart 15. *Roles and Responsibilities Related to the Cost Management Plan*

Names / Roles	Responsibilities
Project Manager: Nikita Saran	The project manager will be responsible for the day to day management of project funds and is authorized to execute the expenditure of project funds as necessary in accordance with the cost management plan and allocated project budget. The project manager may not authorize the use of any additional funding without prior approval from the project sponsor. The project manager will also establish metrics and variance analysis tools in order to provide status updates to the project sponsor and other stakeholders.
Project sponsor	The project sponsor is responsible for the approval of the project's cost management plan. Additionally, he will be responsible for approving the project's budget, corrective actions, and any additional funding that may be needed in case of an emergency or critical situation.
Project team members	The project team is responsible for executing assigned work in accordance with the cost management plan. They are also required to assist the project manager in the implementation of metrics and variance analysis tools to ensure all project deliverables are performed within the allocated budget constraints.
Dulles Corridor contractors Construction Electrical Environmental Esthetics Marketing	The contractors are responsible for providing an initial project cost estimate, which includes all activities associated with the project. Additionally, the contractor shall provide a WBS, which includes all construction work packages and their associated costs. The contractor is responsible for executing work packages in accordance with all approved budget and funding requirements.
Designer (subject matter expert)	The designer will provide his expertise to define accurate cost estimates for all project activities.

4.4.4. Measuring Project Costs

Expert judgment and analogous estimation are the main tools used in establishing the activity costs. The project package evaluations are defined with the combined input of the individuals that have prior knowledge of similar kinds of projects as well as the accounts of similar projects previously executed by FLOW considering scope, budget, duration, and complexity. The estimated costs of individual activities or work packages are summed, and an authorized cost baseline is established.

The budgetary allocation for the execution of the project is 5.25 billion. The cost baseline, which is the approved version of the project budget excluding the management reserve, is measured against the actual project performance. The project manager actively monitors the project performance to ensure that it remains within budget.

Definitions:

- Cost estimate: It is the sum of costs for work packages/activities.
- Cost baseline: It is the cost estimate plus the contingency reserve.
- Budget: It is the cost baseline plus the management reserve.
- Management reserve: It is the budgetary allocation for known unknowns that is used when risks are realized for identified activities within the contract scope of work.

Chart 16. *Cost Baseline*

WBS code	Activity	Cost estimate
1.1	Site design contract	1.71 billion
1.2	Network design – related highway improvement	120 million
1.3	Hardware (utilities and ROW)	130 million
1.4	Contractors (selection of start-up and testing)	240 million
1.5	Implementation (preliminary 1)	0.8 million
1.6	Integration (preliminary 1	0.8 million
1.7	Drive test and tuning (preliminary 1	0.8 million
1.8	Commercial launch (engineering, program management, and contingency)	186.66 million
1.9	KPI monitoring (engineering, program management, and contingency)	186.66 million
1.19	Final acceptance (engineering, program management, and contingency)	186.66 million

Total cost estimate	$5.25 billion
Cost baseline	
Management reserve	
Dulles Corridor upgrade budget	5.25 billion

Note. The contingency reserves were calculated as per each major work package and assuming a 5% rate based on telecom industry standards in the region.

***Chart 17**. Calculation Abbreviations*

Abbreviation	Name	Description
AC	Actual Cost	Total cost incurred in completing the work in an on-status date.
BAC	Budget at completion	Budget for the entire project, when planning is started and the project is baselined.
CPI	Cost Performances Index	A cost efficiency measure expressed as the ratio of earned value to actual cost. (CPI = EV / AC)
EAC	Estimate at Completion	Expected total cost of completing all work of the project.
ETC	Estimate to Complete	Expected cost to finish remaining work of the project.
EV	Earned Value	Planned or budgeted amount for the work actually completed as on-status date.
PV	Planned Value	Planned or budgeted cost of work, scheduled to be completed as on-status date.
SPI	Schedule Performance Index	A schedule efficiency measure expressed as the ratio of earned value to planned value. (SPI = EV/PV)

***Chart 18.** Calculations*

Cost estimate		**5% contingency reserve**
1.71 billion	1,710,000,000	85500000
120 million	120,000,000	6000000
130 million	130,000,000	6500000
240 million	240,000,000	12000000
0.8 million	8,000,000	400000
0.8 million	8,000,000	400000
0.8 million	8,000,000	400000
186.66 million	186,660,000	9333000
186.66 million	186,660,000	9333000
186.66 million	186,660,000	9333000
$5.25 billion	5,250,000,000	262500000

Note. Cost baseline = cost estimate + cost contingency
= 5,250,000,000 + 262500000
= 5,512,500,000 (5.5 billion)

Chart 19. *Management Reserve Calculation*

Risk	Probability	Impact if it occurs ($)
Natural events (hurricanes and earthquakes)	10%	$ 262500000
Materials /Equipment delays	8%	$12000000
Rework	5%	$8,000,000
TOTAL MANAGEMENT RESERVE		$282,500,000

Note. Total calculated budget =
cost baseline + TOTAL MANAGEMENT RESERVE
= $5,512,500,000 + $282,500,000
= 5,795,000,000
= 5.7 billion

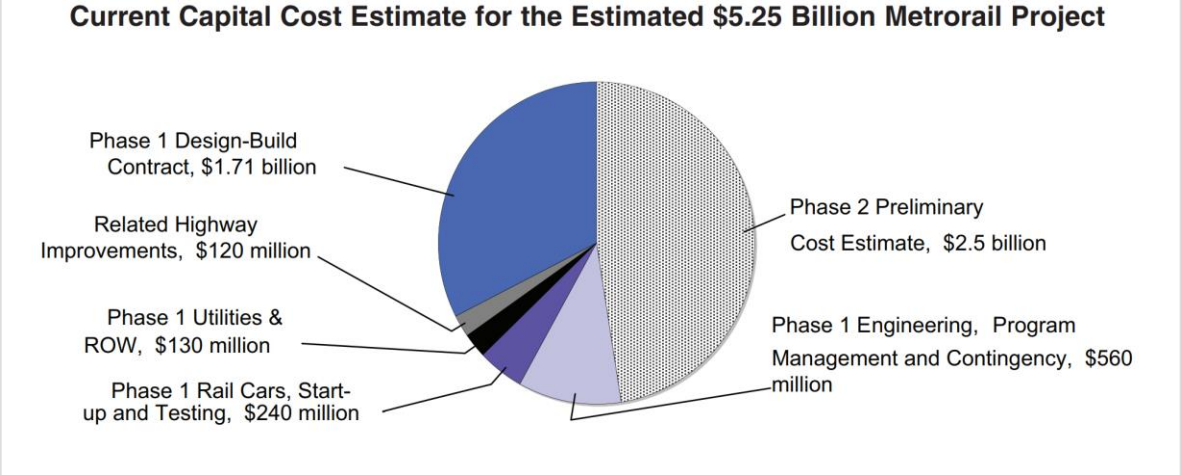


Figure 33*. Cost Estimate Chart.*
Source: Adapted from Dulles Corridor Metrorail Project (n.d.c)

4.4.5. Reporting Format

The end-of-week status reports will include the cost management updates with the particulars regarding the cost variance (CV) and the cost performance index (CPI). The goal is to maintain a CPI > 1. All cost variances outside the limits identified in this section will be reported to the relevant stakeholders to be followed by remedial action.

4.4.6. Cost Variance Process

Cost variances outside the recommended thresholds must be immediately highlighted, reported, and then corrected to return cost and/or schedule performance indexes to acceptable limits. The project manager, with the assistance of the project team, must provide the adequate corrective action to rescind the variances to

accepted limits within a satisfactory period. The cost variance corrective plan details the efficacy of the selected actions and resultant measurements. Upon acceptance of the cost variance corrective action plan by the relevant stakeholders, it becomes part of the updated project plan.

4.4.7. Cost Change Control Process

The LTE upgrade project will use the earned value method approach to calculate cost variances that determine the project's budgetary performance: under budget, at budget, or over budget. This project has a fixed budget and a tight schedule; therefore, any negative variation reported in the cost performance index and cost variance will be considered unfavorable. The project manager has the responsibility of producing a corrective plan to correct negative variances and bring the project's performance back within the budgetary constraints. The project manager calculates the actual costs for all the WBS elements and compares these to the projected baseline costs on a weekly basis. The comparisons are used to generate the data and status reports that form the basis for the CPI and CV ratios. Variances are calculated by deducting the actual costs from the earned value. The appropriate remedial action depends on the scale of variance:

- Positive cost variance (>0): The project work costs less than planned; if this occurs, there must be a detailed examination of the activities and associated costs to ensure the quality is not negatively affected.
- Negative cost variance (<): The project work costs more than planned; if this occurs, there must be an examination of the activities and their related costs to identify what the circumstances causing the increased, unbudgeted expenditure are. This would also require the activation of risk management strategies and possible additional measures, such as CV calculations per work package for better monitoring and control.
- Neutral cost variance (=0): This implies that the budgetary allocations are equal to the actual expenses or that there is zero variance. The project manager and team will continue to manage the project budget expenditure to ensure that the project remains on schedule.

The performance reviews that will be done weekly will include the following:

- Updating the schedule and actual costs associated with the current progress
- Inspections of the work done and inspecting that it matches with the budget
- Communicating project progress and budget uptakes to stakeholders

Figure 34 is a representation of the conditions of the earned value method in controlling costs on the project. The cost change control process follows the official project change request process (scope management plan). The project budgetary changes must be approved by the project sponsor.

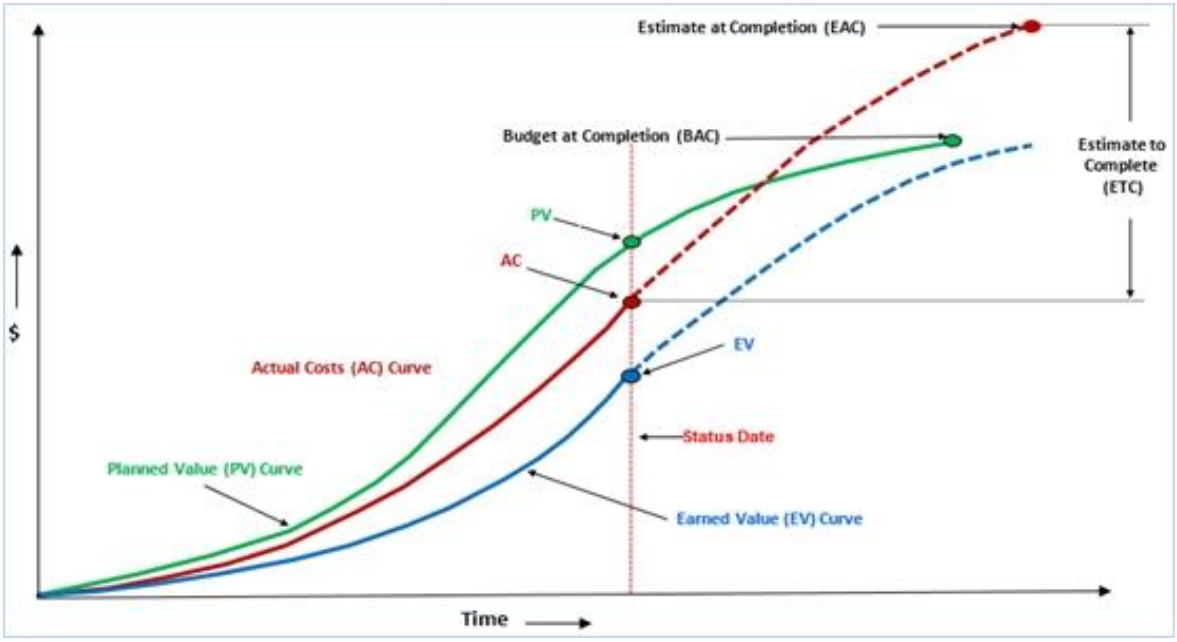


Figure 34. *Earned Value Management- Cost Variance Visual Guidance*
Source: Microsoft Project User Group (n.d.).

4.4.8. Cost Management Plan Approval

The signatures of the people below indicate an understanding in the purpose and content of this document by those signing it. By signing this document, you agree to this as the formal cost management plan for the Dulles Metrorail Project.

Chart 20. *Cost management plan members*

Approver name	Title	Signature	Date
Dheemanth Rajakumar	Project Sponsor		
Nikita Saran	Project Manager		

Revision History				
Version	**Date**		**Reason**	**Executive sponsor sign off**

4.5. Quality Management Plan

The DTP project quality management system describes and defines the QA/QC requirements to be applied to this project by DTP. It references the DTP plans, procedures, and instructions that are used to implement. This project is sensitive regarding transport communication and connection, the ecosystem, and the surrounding community. Bechtel Corporation has a major responsibility to make sure that all codes, standard requirements, and regulations are followed.

4.5.1. Quality Approach

The project manager and the quality manager will define and document all organizational and project specific quality standards for both product and processes. All quality documentation will become part of the project management plan. The quality manager will be responsible for working with the project team to define

metrics, conduct measurements, and analyze results. Within the project lifecycle, quality improvements may be identified by any member of the project team. If an improvement is implemented, the project manager will update all project documentation to include that improvement, and the organizational documentation will be updated.

4.5.2. Project Contractor / Subcontractor Quality Management

As the program manager/grantee for the Dulles Corridor Metrorail Project (project), the Metropolitan Washington Airports Authority has established this quality program plan (QPP) for the project. The QPP specifies all activities and procedures necessary to verify, audit, and evaluate quality for the project and is intended to serve as an overarching program around which other organizations involved in the implementation of the project will design their quality assurance/quality control (QA/QC) program plans.

This QPP is incorporated into the project management plan for the project and is in conformance with FTA's "Quality Assurance and Quality Control Guidelines, February 2002"; FTA's "Project and Construction Management Guidelines, Update"; and the requirements of “ISO 9001-1994, Quality Systems — Model for Quality Assurance in Design, Development, Production, Installation, and Servicing” (transit.dot.gov, n.d.).

This QPP provides specific requirements for the program implementation based upon FTA and Airports Authority policies, including the assignment of primary responsibility for implementation. QA/QC plans from the parties identified above will outline specific requirements for individual activities.

The Airports Authority and Airports Authority suppliers and contractors, including DTP and their subcontractors and suppliers, will define and document the responsibility, authority, and interrelation of personnel who manage, perform, and verify work that is affecting quality. This applies in particular to personnel who require the organization freedom and authority to carry out the following actions:

- Initiate action to prevent the occurrence of any non-conformances relating to product, process, and system quality

- Identify and record problems relating to product, process, and system quality
- Initiate, recommend, or provide solutions through designated channels
- Verify the implementation of solutions
- Control further processing, delivery, or installation of non-conforming products until the deficiency or unsatisfactory condition has been corrected

The Airports Authority and Airports Authority suppliers and contractors, including DTP and their suppliers and subcontractors, will identify resource requirements and provide adequate resources, including the assignment of trained personnel, for management, work performance, and verification activities, including audits.

The Airports Authority and Airports Authority suppliers and contractors, including DTP and their suppliers and subcontractors, will review their quality systems at defined intervals that are sufficient to ensure the systems' continuing suitability and effectiveness in satisfying the requirements of this QPP. These reviews will be performed by managers with executive responsibility.

Each contract for work on the project will be reviewed to determine that specific portions of the QA/QC plan are customized to the project's specific scope of work. The QPP shall provide for the implementation of administrative and control measures during engineering and design.

4.5.3. Supplier Quality Assurance Plan (SQAP)

The project scope for all activities will be conducted under at least seven separate contracts (excluding the rail transport and disposal contracts as well as agreements with the originating rail carrier for infrastructure improvements) and three separate remedial action work plans (RAWPs). The contracts and RAWPs are described below and summarized in Chart 21. The chart also includes the relationship of construction quality assurance (QA), quality control (QC), and health and safety to other phase activities. The activities to be performed under contract 1

(facility site work construction) and contract 2 (rail yard construction) are presented in detail.

Chart 21. *Supplier Assurance Plan,*

Contracts	Contract packages	Remedial action work plans	Construction quality assurance plans	Remedial action health and safety plan
Contract 1	Facility site work construction	Facility site work construction	Construction quality Control/Quality assurance plan	One umbrella RA health and safety plan
Contract 2	Rail yard construction			
Contract 3 A	Processing facility construction	Processing equipment installation and remaining site work		
Contract 3 B	Processing facility operation	Phase 1 dredging and facility operations	Dredging construction quality Control/Quality assurance plan	
Contract 4	Dredging operations			
Contract 5	Habitat construction			
Contract 6	Rail yard operations			

Remedial action work plan for phase 1 facility site work construction. These activities include the following:

- Contract 1: facility site work construction includes general civil work, such as grading, placement and compaction of fill, and paving. Other work activities include wharf area construction, access road construction, river mooring installation, and the construction of a support marina.
- Contract 2: Rail yard construction includes rail construction on the processing facility site property, within the right-of-way of the commercial rail carrier, and rail yard facility work.

All contractors and suppliers who are compliant with the tools and methodology of the SQAP supply the hardware and equipment used for the constructions of the Dulles Metrorail Project.

4.5.4. Quality Requirements

The Dulles Metrorail Project constructor's quality program is designed to ensure that the construction of the Corridor project is successful and the success criteria has quality as the important aspect.

The project must meet or exceed quality requirement criteria. When work does not meet the requirements, the quality team identifies, reports, and initiates action to correct and prevent recurrences. After an issue has been identified, the program forces evaluations and corrective actions and tracks items until they have been brought into compliance.

The Dulles Metrorail Project constructor's project-specific quality program meets all contract requirements for the construction. The program has been reviewed and accepted by the Metropolitan Washington Airports Authority (MWAA). The quality program is based on the U.S. Army Corps of Engineers' proven quality phases of control for construction quality and complies with requirements provided by the FTA quality management system guidelines and the Dulles Corridor Metrorail Project quality program plan.

Notably, the project is ISO 9001:2015 certified. The project is not contractually required to be ISO 9001 certified, and there are very few ISO 9001 certified construction companies in the United States. According to the American Society for Quality (ASQ), "ISO 9001 is the international standard that specifies requirements for a quality management system (QMS). Organizations of all types and sizes find that using the ISO 9001 standard helps them: organize processes, improve the efficiency of their processes, and continually improve".

4.5.5. Implementing Quality Program

Due to its size and complexity, the Dulles Metrorail Project is divided into five operating teams (civil, structures, facilities, systems, and track). These five major project components are further sub-divided into approximately 200 definable features of work (DFOW).

Examples of DFOWs include structural steel erection, masonry, drilled shafts, cast-in-place concrete, etc.

Each DFOW has an associated project specification that dictates the minimum inspections and tests that are to be performed to verify compliance. The Dulles Metrorail Project quality program includes the development of inspection and test plans (ITPs) specific to each one of the DFOWs. These ITPs have been vetted by CRC and accepted by MWAA.

The U.S. Army Corps of Engineers' three phases of control, upon which CRC's quality program is based, includes the following steps for each DFOW on the project:

Phase 1: pre-activity meeting

Phase 2: initial inspection

Phase 3: follow-up inspections

Explanation in detail:

Phase 1: Pre-Activity Meeting

Prior to starting the construction for each DFOW, the Dulles Metrorail Project quality team holds a pre-activity meeting.

Typical attendees at this meeting include the contractor performing the work, safety and quality representatives, environmental managers, survey personnel, field inspectors, and various other management levels. The information covered in these meetings includes reviews of technical specifications, design changes, the work plan, material and equipment inspections, and a review of the ITP.

Following the successful completion of the pre-activity meeting, the contractor is released to begin work, and the inspectors and technicians perform their inspection and testing duties commensurate with the construction of the work.

Phase 2: Initial Inspection

When the first section of work is complete, a formal initial inspection is conducted to verify that this portion of work meets requirements. Attendees at these inspections often include MWAA, other stakeholders, the contractor performing the work, and the Dulles Metrorail Project quality personnel.

During this inspection, workmanship, among other things, is discussed to ensure it meets the client's expectations. The initial inspection affords the contractor the opportunity to correct any minor deficiencies that otherwise may have been caught much later in the process.

Phase 3: Follow-Up Inspection

Following a successful initial inspection, phase 3 is where the follow-up inspections are done. These inspections occur daily (or as the work is being installed) and are documented by the quality team in their inspector daily reports (IDRs). To date, the Dulles Metrorail Project quality inspectors have documented more than 25,000 IDRs. These follow-up inspections ensure that the work continues to meet contract requirements.

4.5.6. Quality Assurance

The requirements for the QA/QC program to be applied to the project are addressed in the Airports Authority quality program plan. The Airports Authority quality program plan requirements are applicable to project participants, including the Airports Authority, DTP, and suppliers and subcontractors.

This plan complies with the guidance contained in the FTA's quality assurance and quality control guidelines and the quality system requirements of ISO 9001-1994 – which are a model for quality assurance in design, development, production, installation, and servicing. DTP, along with the applicable suppliers and subcontractors, has a project quality management system manual that addresses and complies with the requirements of the Airports Authority quality program plan. The Airports Authority project QA/QC and safety manager, assisted by the project QA/QC supervisor, reports to the Airports Authority project director.

The Airports Authority project QA/QC and safety manager has been assigned the authority to ensure that a QA/QC system is established, implemented, and maintained during the course of the project in accordance with the requirements of the Airports Authority quality program plan. In matters related to quality, the project QA/QC and safety manager has complete and ready access to the Airports Authority

project director. DTP has the primary responsibility for implementing a QA/QC program that meets the guidelines and requirements of the FTA and the Airports Authority quality program plan. The Airports Authority will conduct oversight of DTP's quality-related activities to ensure that requirements are met and that the DTP QA/QC program is effective.

The DTP project quality manager's responsibilities include the following:

- The development and maintenance of the DTP project quality management system manual and procedures, instructions, practices, and related documents that define DTP's requirements to achieve the necessary levels of quality on the project
- Conducting QC inspections and tests related to procurement, construction, and installation activities
- The verification of the proper implementation and effectiveness of the DTP project quality management system manual and related procedures and instructions by conducting a comprehensive internal monitoring program that includes audits, surveillances, and reviews of quality-related work activities during design, procurement, construction, installation, and testing
- The identification and recording of non-conformances and quality problems, the initiation of solutions to non-conformances and quality problems, the verification of the effective implementation of solutions, and the initiation of action to prevent quality problems

To implement the project quality management system manual requirements, DTP management is responsible for the following:

- Selecting and assigning well-qualified professionals to perform project tasks
- Assigning qualified individuals to oversee all elements of the work
- Ensuring that the personnel performing quality-related activities have a clear understanding of their responsibilities
- Properly documenting the work and QC processes

The DTP project quality management system manual and implementing procedures and instructions, including revisions, require approval by the Airports Authority and must be in place prior to the start of work (e.g., design control procedures and instructions must be in place prior to the start of the final design, and QC inspection procedures and instructions must be in place prior to the start of construction).

The Airports Authority quality program plan and its implementing procedures and instructions will be reviewed for effectiveness and adequacy by the Airports Authority on an ongoing basis during the course of the project.

Chart 22. *Project Key Performance Quality Metrics and Thresholds*

Process action	**Phase 1**	**Phase 2**	**Phase 3**
Pre-Activity meeting	The contractor performing the work, safety	A formal initial inspection is conducted to verify that this portion of work meets the requirements.	Inspections occur daily (or as the work is being installed) and are documented by the
Initial inspection	Quality representatives, environmental managers, survey personnel, and field inspectors	Workmanship, among other things, is discussed to ensure it meets the client's expectations.	Every time an issue is detected, complete a summary until it is fixed.
Follow-up initial inspection	Everyday summary	The initial inspection affords the contractor the opportunity.	Bi-Weekly or monthly frequency
Inspector report	Zero (0) non-compliance	Construction execution and closeout	Bi-Weekly frequency

Chart 23*. Quality Assurance Log*

Inspection /Audit #	***Date***	***Required value***	***Acceptable (Y/N)***	***Recommendation***	***Date resolved***

4.5.7. Quality Control

Quality control (QC) activities are performed to monitor and record the results of quality assurance, measure quality performance levels, and recommend

necessary changes (corrective actions) to the overall quality management plan. To control project quality, the following actions are carried out:

The quality management plan is executed by the Dulles metrorail quality team as discussed in detail in Section 4.4.5. MWAA requests for the QC plans to be submitted by the subcontractors and vendors. The Dulles Metrorail Project quality team demands submitting inspection test plans for MWAA review weekly and bi-weekly as per phase 1, 2, or 3 discussed in Table 4.5.1.

- Specific responsibilities will be assigned to project members for overseeing and verifying that requirements are delivered.
- Weekly progress reports are to be prepared and communicated to the team to verify that results are accurate and in alignment with the project scope.
- The results obtained from the quality audits shall be analyzed. Immediate corrective or preventative actions are to be implemented, as required in accordance with the established integrated change control process, and change logs will be updated.
- Monitor cost and schedule performance by examining planned versus actual results. The source of variances will be identified, and the necessary corrective actions will be performed.

The tools to be used by the project team for quality management are the following:

- Weekly project meetings: The assigned project members will gather, analyze, and compare data with the identified controls. They need to compare quality control measurements against established control limits and tolerances. All results are to be communicated formally in a report and through meetings.
- The use of control tools, such as control tables: Control tables help monitoring, controlling, and improving processes over the project lifecycle.
- Check sheets: They will be primarily used as a data collection tool.

- Audits: Frequent audits will be carried out to ensure that the project is progressing as planned. (The recommended audit frequency will be at 20%, 40%, 60%, and 90% of the project completion). Audits will include the following:
    - Analyzing quality control data to determine if quality problems exist
    - Identifying process improvements that will increase quality
    - Performing root cause analysis to determine necessary improvements
    - Determining preventative actions to deter future quality issues

Project results must follow established standards and tolerances and will be certified by the designated inspector at each phase. MWAA will conduct audits or surveillances for each phase. MWAA typically submits a rolling audit schedule at each monthly update meeting. The recent QA audit schedule is requested to be submitted in the relevant meetings accordingly.

4.5.8. Quality Management Plan Approval

The signatures of the people below indicate an understanding in the purpose and content of this document by those signing it.

By signing this document, you agree to this as the formal quality management plan for the Dulles Metrorail Project.

Chart 24. *Quality Management Plan members*

Approver name	**Title**	**Signature**	**Date**
Dheemanth Rajkumar	Project Sponsor		
Nikita Saran	Project Manager		

Revision History				
Version	**Date**		**Reason**	**Executive sponsor sign off**

4.6. Resource Management Plan

Bechtel Group organization is built upon time-tested values of excellence and integrity and is committed to operational health and safety, environmental sustainability, resource management excellence, and the Code of Business Ethics (Bechtel Corporation, n.d.a). This means working to the highest ethical standards and being measured by the enduring quality of our projects. Year after year, we are among the safest companies in the industry.

> The Dulles Corridor Metrorail is among the world's most sophisticated rail systems and boasts the latest safety features, such as advanced control systems. Passengers can expect one of the smoothest train rides ever experienced as a result of innovative design and construction. The construction includes five stations, 6 miles (nearly 10 kilometers) of elevated track, and twin tunnels running beneath one of the busiest office and retail centers in the United States—where 700,000 cars travel each day. Construction required three enormous overhead cranes custom-built to lift segments of elevated guideway into place between huge piers. One of the 366-ton behemoths—heavier than a fully loaded Airbus A350—stretched across 12 lanes of traffic over the Capital Beltway. A total of 3 miles (nearly 3 kilometers) of the Phase alignment comprises aerial track, including both the inbound and outbound guideway. (Bechtel Corporation, n.d.c, para. 2-3)

Bechtel group employed more than 2,000 people, most of them from the Washington, D.C., area, and contracted with more than 200 local businesses over the course of the Project (Bechtel Corporation, n.d.c). The organization uses a resource plan to forecast the resources necessary to execute their projects. The resource plan covers the current availability of resources (headcount), their competencies, a recruiting plan, and periods where excess capacity might exist. The resource plan shows whether the resource utilization is based on current, planned, or envisioned work. The resource plan is prepared based on the competence of the resources and not by assigning specific individuals to the projects.

4.6.1. Roles and Responsibilities

All project team members (internal and external) must clearly understand their roles and responsibilities. The competencies required by the project staff, their corresponding roles and responsibilities, and the required materials and equipment were compiled using expert judgment, lessons learned from other projects, network design recommendations, and PMO standard procedures.

The project staff requires competency; their corresponding roles and responsibilities as well as the required materials are identified with the input obtained from expert judgment, lessons learned from other projects, designer recommendations, project estimator feedback, and construction quality standard procedures.

Chart 25. *Resource Management Plan Roles and Responsibilities Summary*

Role	Responsibility
Project sponsor	– He will keep communication and involvement with the project.
Project manager	– The project manager is responsible for evaluating the performance of the project team. – He will ensure that communication mechanisms with all stakeholders are correctly executed.
Design engineer	– The design engineer is responsible for defining and including all construction codes, requirements, and material specs needed for project success in a formal design. – He supports the project manager and project team to define people and material resources required for the project. – To keep communication with the project manager and with any required team member, as required – To advise of any discrepancy or conflict to avoid misunderstandings or delays – To behave and perform in an appropriate and ethical way
Project team	– To participate in the project meetings and provide project updates on a daily basis – To ensure their trainings are valid – To behave and perform in an appropriate and ethical way
Contractor	– To participate in the project meetings and provide project updates on a daily basis – To behave and perform in an appropriate and ethical way
Inspector	– The inspector is responsible for ensuring compliance and communicating any deviation or problem to the project manager – To behave and perform in an appropriate and ethical way
Human resource manager	– The human resource manager will coordinate training times/locations, if required – He/She will provide the training status to the project manager – He/She assists the project manager in identifying training resources and associated costs
Quality manager	– The quality manager assists the project manager in ensuring project quality and communicating it adequately to the team and stakeholders

4.6.2. Staffing Skills and Competencies

Since the Bechtel organizations are more keen on quality deliverance and leading the market as the best quality product assurance for generations to come, selecting appropriate resources is very important. This project is especially a public project funded by the Government of the United States of America, and the end goal is for the project to be a one-of-a-kind world-class Corridor metrorail service in history.

Therefore, the project is highly related to manufacturing operations and not to hydro-geological modifications. There is to be an assurance that the human resources required are identified along with their appropriate skills and experience to fulfill the project requirements. The competency and capability of project team members required to complete assigned tasks and activities within the established time and quality parameters (proficiency) were categorized based on the following levels:

1. Proficient
2. Competent
3. Learner
4. Novice

Chart 26. *Staffing Skills and Competencies*

Skills	Project manager	Design engineer	EHS inspector	Field engineer	Inspector	Scheduler	Cost controller	Contractor	Resource manager	Quality Manager
Leadership/Management	1	1	1	1	1	1	1	2	2	1
Budgeting	1	2	2	2	2	2	2	2	2	1
Scheduling	1	2	2	2	2	1	2	2	3	3
Executive communication	1	2	2	2	2	2	2	1	1	1
Quality experience	1	2	2	2	2	2	2	2	1	1
Compliance experience	1	1	1	1	1	2	2	2	2	1
Safety experience	1	2	1	1	1	3	3	1	3	2
Design experience	2	1	3	2	2	2	2	2	4	4
Construction codes	2	1	2	2	1	2	2	1	4	4

4.6.3. Assumptions and Constraints

Chart 27. *Project Assumptions and Constraints*

Resource type	Topic	Assumption/Constraint
Human resources	Staff participation	Project internal staff assigned to the project will be able to participate as they are required.
	Training funding	The available training funds will be enough to prepare the project participants, as required.
	External staff	External contractors will be available to participate during the proposed time, and no additional time or replacement will be required.
	Regular work week	A regular workweek will be from Monday through Friday, 40 hours in duration.
Other resources (materials)	Material availability	It is assumed that materials required for the daily project administrative processes are always available and supplied by Bechtel Corporation's engineering program. It is assumed that construction materials will be available at the time of the project execution.
	Material specifications	The only materials required for the construction execution are the rocks (to be defined in the design) and the erosion control measures to be installed in the project. All material required for the construction execution is to be provided by the selected contractor, in compliance with the specifications to be provided by the designer.

4.6.4. Project Organization

The Dulles Metrorail Corridor Project organizational table assists the project team in identifying and documenting key project team members, management, and other stakeholders.

As part of identifying and documenting the overall project governance, roles, and responsibilities, the organizational table included below displays the project domain.

The responsible, accountable, consulted, and informed matrix table or responsibility assignment matrix table (RACI matrix table) below shows the relationship between project tasks and team members.

The project manager must review and approve any changes in the project responsibilities; all relevant documentation must be updated with any approved changes.

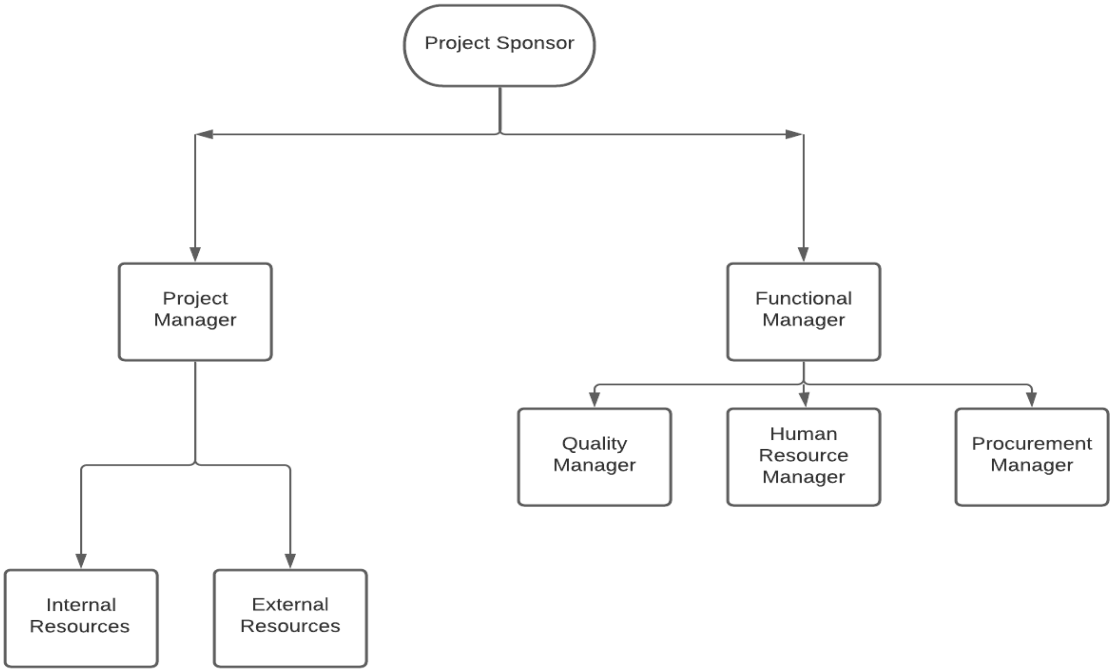


Figure 35. *General Project Organizational.*

Chart 28. *RBGR RACI Table*

Activities	Project manager	Design engineer	EHS inspector	Field engineer	Permitting Expert	Inspector	Scheduler	Cost controller	Contractor	Resource manager	Quality manager
Requirement gathering	R	R	I	I	C	I	I	I	C	R	R
Change requests	R	C	I	C	C	C	C	C	C	C	C
Site management	R	I	I	I	I	I	I	I	I	I	I
Permits/ Approvals	A	C	C	I	R	C	C	I	I	I	I
Project scope	R	C	C	C	C	C	C	C	I	I	I
Project communication	R	C	C	I	C	C	C	C	I	I	I
Project quality	A	C	C	C	C	C	I	I	I	I	R
Stakeholder management	A	I	I	I	I	C	I	I	I	R	I
Accounting	A	C	I	I	I	I	C	R	I	I	I
Status reports	A	C	C	I	C	C	C	C	C	C	C
Manage site workers	A	I	I	I	I	C	I	I	I	I	I
Procurements	A	I	I	I	I	I	C	C	I	R	I

R: Responsible for completing the work
A: Accountable for ensuring task completion/sign off
C: Consulted before any decisions are made
I: Informed of when an action/decision has been made

4.6.5. Resource Estimate

The project circumstances in relation to funding, scheduling, and scope requirements stipulate that the human resource estimation be based on expert judgment and the use of published estimating data. The utilization of smart phones has minimized the need for communication equipment and office supplies: laptops, printers, scanners, etc. Contractors must each have their own smart phone, and they will be provided local SIM cards by the customer for the duration of the project. The local and remote teams will engage through WhatsApp chat groups, enabling the instantaneous sharing of pictures and videos and installation statuses.

Due to the proposed project conditions in regard to funding, scheduling, and scope requirements, the human resource estimation is to be performed based on expert judgment and the review of lessons learned documentation. All materials directly related to administrative project processes, such as office supplies, communication equipment, etc., are part of the Dulles Metrorail engineering program supplies inventory, always in stock and available to the Dulles Metrorail project staff.

The materials required for the Dulles Metrorail Project construction execution are to be defined and estimated by the project designer and included in the project certified drawings and specifications to be used by the contractor. The project contractor will be responsible for supplying all required project material in compliance with the requirements detailed in the quality management plan and drawings and specs to be prepared by the designer.

Details of the resource allocation and human resource hours per task are included in the resource table.

Chart 29. *Estimated Human Resources,*

Role	Amount of needed resources	Type of resource
Project manager	1	Internal
Design	10	External (outsource)
Inspector	20	1 internal (1 inspector for each department, a total of 20 departments)
Human resource leader	10	Internal (1 head of HR, head for each department – 20 departments)
Quality assurance professional	4	Internal 1 per 5 departments (5/20 - 4)
Scheduler	4	Internal 1 per 5 departments (5/20 - 4)
EHS inspector	4	External (outsource) 1 per 5 departments (5/20 - 4)
Cost controls	3	Internal
Permitting expert	4	External (outsource)
Field engineer	10	Internal
General contractor team	20	External (outsource)

4.6.6. Staffing Management

4.6.6.1. Staff Acquisition

The Dulles Metrorail Project will require internal and external personnel to perform the required project activities. The project manager should work with the human resource team to advertise positions and perform interviews. Staff may also be replaced by redirecting resources from within or outside the project, or their workload may be absorbed by other staff. The project manager will consider with the HR team to source the adequate staff for the project roles.

4.6.6.2. Virtual Team Management Process

Virtual meetings are an integral part of the project processes, since project team members like the project manager, quality assurance manager, project sponsor, network design group, and human resource manager will not be on the island. Conferences will be through Skype, Google Meetings, WhatsApp group chats, Zoom meetings, Bluejeans Meetings, and Microsoft Teams meetings. All stakeholders are responsible for having the corresponding tools for the scheduled virtual meetings.

4.6.6.3. Resource Calendar

The table below summarizes the resource allocation aligned with the proposed schedule per project task.

Chart 30. *General Resource Calendar Table*

WBS #	Task	Total duration (days)	Human resources	Start	Finish
1.1.1	Project planning	30	Project manager, design engineer, scheduler, cost control, quality manager, resource manager, permitting expert, and legal counselor	06/20/ 2020	07/20/2020
1.1.2	Procurement	21	Legal counselor, procurement manager, resource manager, and project manager	07/21/2020	08/11/2020
1.1.3	Document management	45	Project manager and 1 additional resource (project team)	08/12/2020	09/26/2020
1.2.1	Certified drawings and specifications	20	Design engineer and project manager	09/27/2020	10/17/2020
1.2.2	Manage permits	40	Permitting expert and inspector	10/18/2020	11/27/2020
1.3.1	Mobilization	4	3 contractors, 1 inspector, 1 project inspector, 1 project coordinator, and 1 safety inspector	11/27/2020	12/01/2020
1.3.2	Site preparation	5	Contractors (8), safety inspector, scheduler, and construction inspector	12/01/2020	12/06/2020
1.3.3	Damage restoration	10	Contractors (15-20), safety inspector, project coordinator, project scheduler, and construction inspector	12/06/2020	12/26/2020
1.4.1	Final approvals	3	Contractors (8-10), safety inspector, construction inspector, permitting expert, and project manager	12/26/2020	12/29/2020
1.4.2	Project closing	12	Project coordinator, project scheduler, procurement professional, project inspector, and project manager	12/29/2020	01/10/2021

4.6.6.4. Team Development Plan

The project manager monitors and documents team member interactions and seeks to improve staff competencies and the overall collaborative environment.

4.6.6.5. Skills and Competency Development

The project manager presumes that the project team members, internal or external resources, are fully competent within their specific roles. The staff have been successfully utilized in similar projects in the recent past, and therefore, no additional competency development is required.

4.6.6.6. Performance Reviews

The project manager monitors, manages, and reviews the overall performance of the project during the project's lifecycle. The field engineer provides daily status reports of the activities and the performance of the contractors. The daily management of assigned project staff and contractors is the responsibility of the project manager. However, the HR manager is accountable for the internal staff, their evaluations, performance issues, recognition, promotions, and disciplinary actions. Managing resources includes the appraisal of the employees' performance during the project performance. The personnel report provides the basis for managerial decisions on how to manage the project team. Employee performance metrics include the following:

Quality of completed activities

- Work behavior
- Job-related attributes

After conducting the employee performance reviews, the PM should carry out the following activities:

- Provide feedback to employees about the areas under review
- Take corrective actions where necessary
- Reward excellent performance to encourage continued brilliance

4.6.6.7. Recognitions and Rewards

All workers irrespective of whether they are internal or external are eligible for rewards and recognition. However, in terms of monetary recognition and rewards, the external workers will receive their rewards and recognition as per the employment contract paying head office or through the respective salaried organization. The internal workers will receive rewards and recognition as per Betchel Group standards. The project employees are rewarded for excellence in execution and performance with economic compensation based on the respective protocols and standards.

Through the project, the external and internal employees will be treated equally and will not be discriminated in terms of goodies distributed across the onsite, recognition, celebrations like Thanksgiving and Christmas, and food. They will be eligible to participate in all employee morale programs.

4.6.6.8. Conflict Management

Conflicts during projects are usually caused by personality differences, role conflict, limited resources, lack of information, poor communication, and high stress levels. Although proper planning, good communication, and team building exercises can reduce the occurrence of conflict, it may still emerge. The PM is responsible for managing conflict that can negatively affect the team or the project's success. The effectiveness of a conflict resolution approach depends on the situation, but at its root, it is defined by the following actions:

- Evaluating the situation, including gathering data and relevant information, and observing all parties involved
- Actively listening and communicating
- Partnering with the team to build trust, create leaders, and minimize conflict
- Negotiating

4.6.6.9. Resource Management Plan Approval

The signatures of the people below indicate an understanding in the purpose and content of this document by those signing it. By signing this document, you agree to this as the formal resource management plan for the Dulles Metrorail Project.

Chart 31. *Resource Management Plan Approval members*

Approver name	**Title**	**Signature**	**Date**
Dheemanth Rajkumar	Project Sponsor		
Nikita Saran	Project Manager		

Revision History				
Version	**Date**		**Reason**	**Executive sponsor sign off**

4.7. Communication Management Plan

4.7.1. Introduction

The Dulles Metrorail Corridor Project is a high-level project and involves the public interest due to which communication becomes very important and is responsible for media publication. The communication management plan coordinates the communication structure for the project. It serves as a template for the divergence of information to relevant stakeholders throughout the project. Changes may be made to the plan when necessary. The communication management plan details how project information is collected, reported, and distributed to the relevant stakeholders. The project is time-sensitive, and therefore, open communication channels and frequent meetings are encouraged.

4.7.2. Approach

The communication requirements are documented in accordance with the recommendations included in the PMBOK® Guide. The project manager is proactive in ensuring effective communication on the project. As with most project plans, updates or changes may be approved as the project progresses. The project manager is responsible for managing all proposed and approved changes to the communication management plan.

4.7.3. Assumptions and Constraints

The following assumptions and constraints are considered in this communication management plan:

- All project communication activities will occur within the project's approved budget, schedule, and resource allocations.
- Communication activities will occur in accordance with the guidelines detailed in the communication matrix to ensure the adherence to schedule constraints.
- The project sponsor must approve all deviations from the timelines that may result in excessive costs or schedule delays.

4.7.4. Communication Management

4.7.4.1. Standardization Process

Bechtel Corporation enforces the standardization of processes as a tool to simplify the complexities of project management communication. The project team will use the Bechtel Corporation standard organizational formats and templates for all formal project communication.

4.7.4.2. Stakeholder Identification Requirements

As part of the project stakeholder identification and by using his expert judgment and following Bechtel Corporation communication standards, the project manager will determine the frequency and the methods of communication to be implemented.

As part of the stakeholder registry process, the project manager will identify stakeholders' requirements in order to align the communication methods to their expectations. This feedback will be maintained by the project manager in the project's stakeholder register.

Chart 32. *Project Stakeholders' Identification and Requirements*

Stakeholder type	**Responsibility**	**Stakeholder information requirements**	**Timeframe / Frequency**
Project Sponsor Approver: Dheemanth Rajkumar	He is the champion of the project that authorizes the project, funding, and possible changes. He will be available to obtain constant updates from the project manager and project team.	To receive written project updates	At least in a monthly basis
		To provide input to requirements	Prior to the completion of a significant project milestone
		To approve project deliverables	Upon completion of a significant project milestone
Project manager	She coordinates the overall project activities and is responsible for providing updates and keeping stakeholders aligned with project requirements and status. She will resolve any conflict and will keep the community informed.	To receive updates on the project progress	In a daily basis
		To ensure the communicating status to the project sponsor	Monthly or more frequent if needed
		To direct the communication with the project team	In a daily basis
Design engineer	He/She will ensure that all project requirements are included in the project design and that all documents are updated as required.	To receive updates on project progress and to provide inputs or recommendations while updating the drawings and specs as needed	As required by the project manager, more frequent if needed, or upon completion of a significant project milestone
Permitting expert	To ensure the provision/communication of the permitting strategy and to ensure compliance with all regulations and standards	To receive updates on project progress and to provide inputs or recommendations	As required by the project manager or upon completion of a significant project milestone
Functional managers (human resources, quality, procurement, and legal)	To provide support to the PM regarding internal resources and technical aspects that may affect operation	To receive updates on the project progress	Weekly
		To provide input to requirements	Weekly or as needed

Stakeholder type	Responsibility	Stakeholder information requirements	Timeframe / Frequency
Tech team members (scheduler, cost controls, and field engineer)	To keep their documents and activities up to date and documented and ensure the providing status on a timely manner	To provide and receive updates on the project progress	Weekly
Quality assurance professional	To perform Q & A audits and prepare and present reports	To provide and receive updates on the project progress performance	Weekly
Community	To represent the interest of users	To receive updates on the project progress	Monthly basis or as required
		To provide feedback	As they require (they will contact the project manager)
Inspectors	To communicate field observations and/or provide feedback in a promptly manner	To provide and receive updates on the project progress	Bi-weekly or as needed
		To direct the communication with the tech team	Bi-weekly or as needed
Regulatory agencies	To identify environmental regulation/condition requirements and provide their recommendations	To provide and receive updates on the project progress in accordance with permit conditions	As they require (they will contact the project manager)
		To direct the communication with the technical team and PM	

4.7.4.3. Communication Escalation Process

Efficient and timely communication is the key to successful project completion. As issues or complications arise regarding project communication, it may become necessary to escalate the issue if a resolution cannot be achieved within the project team. In order to ensure that projects stay on schedule and issues are resolved, the project will use its standard escalation model to provide a framework for escalating communication issues. The table below defines the priority levels, decision authorities, and timeframes for resolution.

Chart 33. *Communication Escalation Process Summary,*

Priority	Definition	Decision authority	Timeframe for resolution
Priority 1	Major impact to the project or business operations. If it is not resolved quickly, there will be a significant adverse impact to the revenue and/or schedule.	Vice president or higher	Within 4 hours
Priority 2	Medium impact to the project or business operations that may result in some adverse impact to the revenue and/or schedule	Project sponsor	Within one business day
Priority 3	Slight impact that may cause some minor scheduling difficulties with the project but no impact to the business operations or revenue	Project manager	Within two business days
Priority 4	Insignificant impact to the project, but there may be a better solution.	Project manager	Work continues, and any recommendations are submitted via the project change control process.

4.7.4.4. Issue Log

The project team maintains an issue log (the template below) to record all issues confronted in the project life cycle. Relevant personnel are assigned according to their expertise, experience, and competences to ensure the success of the project despite disruptions. The project manager is responsible for managing the issue log with the support of the project team.

Chart 34. *Issue Log Template*

#	Description	Reported by	Date	Responsible officer	Priority	Actions or progress notes	Status	Date resolved

4.7.4.5. Project Team Directory

To ensure timely and agile communication, a project team directory will be prepared and updated as required. A template is included in the table below for reference.

Chart 35. *Project Team Directory Template*

Role	Name	Title	Organization/Department	Email	Phone

4.7.4.6. Project Communication Matrix

***Chart 36**. Communication Matrix,*

Communication type	***Objective of communication***	***Channel***	***Frequency***	***Audience***	***Owner***	***Deliverable***	***Format***
Kickoff meeting	To introduce the project team and the project and review the project objectives and management approach	• Face to face	Once	• Project sponsor • Project team • Stakeholders	Project manager	• Agenda • Meeting minutes	• Soft copy archived on the project SharePoint site and project website
Project team meetings	To review the status of project activities with the team	• Face to face • Conference call	Weekly	• Project team • Inspector • Designer	Project manager	• Agenda • Meeting minutes • Project schedule	• Soft copy archived on the project SharePoint site and project website
Technical design meetings	To discuss and develop technical design solutions for the project	• Face to face	As needed	• Project technical staff	Technical lead	• Agenda • Meeting minutes	• Soft copy archived on the project SharePoint site and project website
Lessons learned sessions	To record all good and bad decisions, results associated, and further analysis to be used as guidance for other projects	• Face to face	As needed	• Project sponsor • Stakeholders • Project manager • Any team member as required	Project manager	• Lessons learned • Document updates	• Soft copy archived on the project SharePoint site and project website

Communication type	***Objective of communication***	***Channel***	***Frequency***	***Audience***	***Owner***	***Deliverable***	***Format***
Project status meetings	To provide a report on the project status to the project sponsor	• Face to face • Conference call	Monthly or more frequent if needed	• Project sponsor • Stakeholders • Project manager • Any team member as required	Project manager	• Slide updates • Project schedule	• Soft copy archived on the project SharePoint site and project website
Project status reports	To report the status of the project including the activities, progress, costs, and issues	• Email • Face to face • Conference call	Daily, weekly, and monthly	• Project sponsor • Project team • Stakeholders	Project manager	• Project status report • Project schedule	• Soft copy archived on the project SharePoint site and project website
Post-Review report	To measure, analyze, and record actual vs planned performance and results after each phase completion and at project closeout	• Face to Face	Every time a project phase is finished and at the end of the project	• Project sponsor • Stakeholders • Project manager • Any team member as required	Project manager	• Report and record results	• Project sponsor • Stakeholders • Project manager • Any team member as required

4.7.4.7. Communication Methods and Technologies

A project management information system (PMIS) is the coherent organization of the information required for an organization to execute projects successfully. A PMIS is typically one or more software applications and a methodical process for collecting and using project information.

Bechtel Corporation is an American engineering, procurement, construction, and project management company. Bechtel Corporation keeps a SharePoint platform available for all its projects as a way to provide updates, store data, and conduct project communication through a standard process. For external resources, a link will be provided to allow access as required and established by the Bechtel Corporation procedures.

4.7.4.8. Communication Monitoring and Reporting

The project's work performance results are communicated to stakeholders through performance/status reports. The reports should provide all information needed by stakeholders to the level of detail required by them. From the project management plan, the information required to identify the report performance baselines is obtained. Performance reports follow the Bechtel Corporation standards and procedures and include the following communication guidelines:

Chart 37. *Recommended Reporting*

Report	Measure	Frequency	Responsibility
Project performance, processes, & forecasts	Earned value, planned value, actual cost, SPI, CPI, schedule variance, and cost variance	Weekly	The project manager with the support of the required project team members
Lessons learned review	Good and bad decisions and associated results	At the end of the project	The project manager with the support of the required project team members
Post-project review	Baseline opportunities	At the end of every project phase and at the project closeout	The project manager with the support of the required project team members

4.7.4.9. Glossary of Communication Technology

Chart 38. *Glossary of Bechtel Corporation Communication Terminology*

Terms	Definitions
Communication management plan	Portion of the overall project management plan that details how the project communication will be conducted: the participants, frequency, and method of communication
Communication	The imparting or exchanging of information or news; ideally, the information received should match the information sent. It is the responsibility of the sender to ensure this takes place.
Stakeholder	Individuals or groups involved in the project or whose interests may be affected by the project's execution or outcome
Escalation	The process that details how conflicts and issues will be passed up to the management chain for resolution as well as the timeframe to achieve resolution

4.7.4.10. Sponsor Acceptance

Chart 39. *Communication Management members*

Approver name	Title	Signature	Date
Dheemanth Rajkumar	Project Sponsor		
Nikita Saran	Project Manager		

Revision History				
Version	**Date**		**Reason**	**Executive sponsor sign off**

4.8. Risk Management Plan

4.8.1. Introduction

The PMBOK® Guide (PMI, 2017) defines a risk as an uncertain event or condition that, if it occurs, could have a positive or negative effect on one or more project objectives. Project risk management is the process of identifying, assessing, responding to, monitoring, and reporting risks over the lifecycle of the project.

The Airports Authority will conduct an evaluation of project risks and initiate the development and implementation of a risk management plan, including contingency management procedures. The FTA conducts its own risk assessment as part of its oversight of the project and will work with the Airports Authority to develop a mutually agreed upon project execution strategy that contains a description of the required contingency and risk management process.

The risk management plan defines how risks associated with the construction of the Dulles Metrorail Corridor Project are identified, analyzed, and managed. It outlines how risk management activities will be performed throughout the lifecycle of the project while providing templates and practices for recording and prioritizing risks.

The project manager, alongside the project team, created the risk management plan in the planning phase; however, the risk management plan will be monitored and updated throughout the project lifecycle. As such, this risk management plan provides the methodology to identify and quantify the risks to the project, determine the consequence and associated probability, and develop mitigation strategies. Opportunities will be managed as well to ensure project success and efficiency.

4.8.2. Project Background

According to Dulles Corridor Metrorail Project (2019):

> The Dulles Corridor Metrorail Project (DCMP) is an extension of Washington Metropolitan Area Transportation Authority (WMATA) heavy rail system from the current terminus at Wiehle Avenue Station through Washington Dulles International Airport ("Dulles Airport") to a terminus in eastern Loudoun

> County. DCMP includes new stations: Reston Town Center, Herndon, Innovation Center, Dulles Airport, Loudoun Gateway (Route 606), and Ashburn (Route 772) Stations. The project also includes a maintenance and storage yard facility near Dulles Airport, wayside facilities (including traction power substations, tiebreaker stations, and stormwater management ponds along the alignment), 5 new parking facilities with a total of 8,900 parking spaces, and sixty-four new railcars. (p. 2)

Bechtel Corporation (2012) stated that:

A global leader in the rail industry, Bechtel has successfully completed some of the largest and most complex rail projects in the world, including the San Francisco BART system; Athens Metro; Jubilee Line Extension on the London Underground; West Coast Main Line Route Modernization; and High Speed 1. (para. 7)

The Dulles Corridor Metrorail will be among the world's most sophisticated rail systems and promises the latest safety features, such as advanced control systems. Passengers can expect one of the smoothest train rides ever experienced as a result of innovative design and construction. The project includes new stations, “6 miles (nearly 10 kilometers) of elevated track, and twin tunnels running beneath one of the busiest office and retail centers in the United States—where 700,000 cars travel each day” (Bechtel Corporation, n.d.c, para. 3).

The project is said to rank as one of the largest construction projects in the United States. The project is said to mark as the first use in the United States of technology co-developed by Bechtel that enabled secure, two-way communication and data exchange between surveyors and satellite office staff and GPS-guided construction machinery, which greatly enhanced construction productivity and quality.

4.8.3. Approach

The Dulles Corridor Metrorail Project risk management plan process methodology was based on the elements included in the PMBOK® Guide Sixth Edition and standards from the Project Management Institute (PMI). The risks

associated with the project are to be identified as early as possible in the project to minimize their impact, and they will continue throughout the project lifecycle. Due to the schedule and cost constraints, the risk management process meeting updates are to be held at least once a week. The steps for accomplishing the risk management plan objectives are outlined in the following sections.

4.8.4. Project Constraints

The Dulles Corridor Metrorail Project intends to connect many different places. It includes new stations, 6 miles (nearly 10 kilometers) of elevated track, and twin tunnels running beneath one of the busiest office and retail centers in the United States (Bechtel Corporation, n.d.c). The project has several limitations, as outlined in Chart 40, to consider in the risk management plan process:

Chart 40. *Project Constraints*

Constraints	
Schedule	Project execution must be completed within January 10, 2021 to avoid communication delays and extension.
Cost	The budget cannot exceed $5.25 billion.
Quality	All design specifications must be implemented. Any execution fault may affect the public image of the project sponsor and can trigger potential environmental or safety problems.

4.8.5. Roles and Responsibilities

During the risk management process, stakeholders, with their various roles and responsibilities, are required to collaborate in the risk identification process from the early stages of the project.

The following table summarizes the roles and responsibilities concerning the project's risk management plan.

Chart 41. *Roles and Responsibilities*

Roles	Responsibility
Project manager	He will have the overall responsibility for the preparation, establishment, and active execution of the risk management plan. He/she is also responsible for ensuring risk communication and the corresponding reporting performance.
Risk manager specialist	The risk manager specialist will provide support to the project manager in preparing and executing the risk management plan.
Project team (safety officer, environmental officer, scheduler, cost engineer, project engineer, and designer)	Specific responsibilities may include the following activities: • Actively participating in the risk management meetings • Identifying risks • Supporting the risk manager specialist in clarifying and documenting risks • Providing the status on risk mitigation actions • Communicating the status to risk owners • Participating in the risk closure process
Contractor (s)	The contractor(s) are responsible for providing the risks related to his/their construction activities, and they will report newly found risks immediately.
Design firm	The design firm(s) are responsible for providing the risks related to his/their construction activities, and they will report newly found risks immediately.
Sponsor	The sponsor will define his/her constraints and requirements to ensure they are adequately taken into account in the risk management process.

4.8.6. Risk Management Process

4.8.6.1. Risk Identification

The roles and responsibilities of the stakeholders towards the risk management plan are defined and communicated (refer to Section 4.8.5). Due to the short duration of the project, the risk identification activities will be continuously revised in the weekly team meetings. All assumptions made to identify risks are to be validated and reviewed continuously in the meetings to have the uncertainties under control. The risk identification process will include all risks and opportunities pertaining to the construction execution as well as the ones after project closure. Risks will be coded in the risk breakdown structure, and a risk register will be prepared to include all risks (threats and opportunities) identified during the project lifecycle.

The project will identify as many risks as possible, since the early stages of the project, and they will be reviewed and evaluated by the project manager and his team. The risk identification/management process will mainly depend on the outcome of stakeholders' risk workshop meetings. In those meetings, the risk breakdown structure will be used as a guiding tool (prompt list), along with brainstorming, interviews, and the review of similar risks that existed in previous projects (lessons learned).

4.8.6.2. Risk Breakdown Structure.

Risk categories are to be structured with the risk breakdown structure (RBS), which is a hierarchical representation of potential risk sources. The project's RBS provides several additional insights into the assessment of risk exposure on the project that will be used in the risk identification and in the prioritization process.

Chart 42. *Risk Breakdown Structure,*

RISK LEVEL 1	RISK LEVEL 2	RISK LEVEL 3
External risks	1. Environment	1.1 Natural environment/weather
		1.2 Site and facilities
		1.3 Legal (regulatory) and compliance
		1.4 Waste management
	2. Community	2.1 Land limitations
		2.2 Community requirements/concerns
Internal risks	3. Organization and management	3.1 Schedule and resource constraints
		3.2 Financial constraints
		3.3 Management experience
	4. Personnel and materials	4.1 Personnel experience and qualifications
		4.2 Personnel and material availability
		4.3 Quality of material resources
		4.4 Safety/security requirements
	5. Engineering and design	5.1 Project design requirements
		5.2 Construction permits and conditions

4.8.6.3. Qualitative Risk Analysis

Through qualitative risk analysis, risk prioritization will be assessed using the probability of occurrence, the results of which are included in the risk register. The risk management specialist and project manager, with input from the project team and other stakeholders, will assess the probability and impact of occurrence for each identified risk. Probability and impact scales are defined in the following sections.

4.8.6.4. Probability Scales

Risks (threats) and opportunities are identified and managed in this plan. Probability and impact scales for both situations were prepared based on several conditions. The probability scales for this project are based on the likelihood of the risk to happen within certain timings covering the short duration of the project, which is 8 weeks and the existing limitation that requires that schedule to be kept. The scoring (scale) of the risk probability and impact used in the risk register was a standard method based on defining clear ratings and logical economic effects on the project.

Chart 43. *Risk Probability Scale*

PROBABILITY	
1	An event we do not expect to happen in the next 8 weeks
2	An event we do not expect to happen in the next 4 weeks
3	An event we expect to happen anytime

The project impact scales were aligned with project circumstances with regard to the economic impact and risk occurrence. The project budget is limited to $5.25 billion, based on the fact that approximately 204 days of project duration (at 5 days a week, 8 hours a day) is equivalent to 656 million per week, 131 million a day, and 16 million per hour. (5,250,000,000 / 8 = 656,250,000; 656,250,000/ 5= 131,250,000).

Chart 44. *Risk Project Impact Scale*

IMPACT	
1	An impact of less than $656 million
2	An impact between $657 million and $700 million
3	An impact higher than $700 million

Risks that fall within the RED and YELLOW zones will have risk response planning, which may include both a risk mitigation and risk contingency plan.

4.8.6.5. Project Opportunities

Probability and impact scales for project opportunities were also defined taking into consideration cost savings, sponsor company prestige, and project quality.

Chart 45. *Project Opportunity Probability Scale*

PROBABILITY	
1	Project benefits will sustain from 5-10 years.
2	Project benefits will sustain from 10-20 years.
3	Project benefits will sustain for more than 30 years.

The project impact scales regarding the opportunities were aligned to project circumstances in regard to the sponsor's public image and prestige. Public image was related to the economical investment of the project.

Chart 46. *Project Oportunity Impact Scale*

IMPACT	
1	Positive public image is translated in economical savings estimated as $700 million.
2	Positive public image is translated in economical savings between $700 million and $800 million.
3	Positive public image is translated in economical savings higher than $801 million.

4.8.6.6. Probability and Impact

Based on the project objectives and sponsor's expectations, and through the brainstorming of all stakeholders, the probability and index scales were defined as indicated in the table below.

Chart 47. *Risk Probability and Impact Result Scale*

P x I (probability x impact)	
From 1 to 3	Green
From 4 to 6	Yellow
From 7 to 9	Red

Risks that fall within the RED and YELLOW zones will have risk response planning, which may include both a risk mitigation and risk contingency plan.

Chart 48. 3Probability of Opportunities and Impact Result Scale

P x I (probability x impact)	
From 1 to 3	Green
From 4 to 7	Yellow
From 8 to 9	Red

Opportunities that fall within the RED and YELLOW zones will be the ones that shall be considered to ensure taking advantage of them.

4.8.7. Risk Identification (Risk and Opportunity Register)

All risks and opportunities that may affect the project outcome or arise from the project assessment are to be documented in the project's risk register (log). The opportunity side of the register offers many benefits. It can offset risks, create a pool of money to serve as an incentive pool for the team to enhance profits, or act as a funding source to drive additional value to the project. Often, teams are so focused on risks that they fail to consider them as opportunities. Having an actively managed risk and opportunity register encourages project teams to look for and consider opportunities that can enhance the value of the project.

Finally, the register provides an effective tool for sharing knowledge. Everyone on the team contributes, adds, and views information contributed by others. The register is also the basis for weekly or monthly meetings on risk management. At the end of the project, the register provides teams with a record of how risks were managed and the gains realized through the process for the client and the individual partners.

The risk and opportunity register was prepared based on the proposed activities expected for this type of project, constraints, and conditions. Prioritization was based on their likelihood of occurrence and degree of potential impact.

Updates to the register will be performed on a weekly basis due to the compromised project schedule and the criticality of the project. The project risk register and opportunity register are included in Chart 49 and 50.

Chart 49. *Risk Scoring*

Qualitative risk scoring scale			
Rating	**Probability**	**Time impact**	
Very high	> 50%	> 6 months	
High	25% to 50%	3 to 6 months	
Medium	10% to 25%	1 to 3 months	
Low	5% to 10%	1 week to 1 month	
Very low	< 5%	< 1 week	

Chart 50. *Project Risk Register and Opportunity Register*

Specific risks (suggested by the checklist or otherwise identified)						**Treatment action**					**Post-Treatment residual risk scores**		
Objective	**Risk ID (OP code+nnn)**	**Comments/Potential mitigation**	**Risk description (cause/risk/effect)**	**Status**	**Project manager (surname, first name)**	**Action description**	**Project manager (surname, first name)**	**Probability**	**Impact**	**P x I**	**Probability**	**Cost**	**Time**
Affordable, good value for money scheme	WLR -001	Industrial spur clients in the corridor have not existed in decades. This should be addressed in the Dulles Metrorail Project railroad agreement.	Poor ground condition of Central Windsor and ability to form the route	Open	Saran, Nikita	Performing a suitable phase 1 and 2 geological/geotechnical assessment to assess ground conditions. Appropriate design	Saran, Nikita	3	2	6	Medium	High	High
A new single station for Windsor	WLR -002	The shared corridor is very small: from Ninth Street to Alston Ave (< 3 miles) It is known that they will use two tracks. The risk is if they change their plans from what we have used for our assumptions. Principal issues would be in regards to grade separations and mandates that come from this. There is a traffic separation study in progress in Durham that could lead to future grade separation needs in the design process. Risk percentage is based on the likelihood of two future grade separations (by others) requiring a change to the plan and LRT profile.	The proximity of the river to the proposed route	Open	Saran, Nikita	Acquiring an environmental study to inform the risk	Saran, Nikita	3	3	9	High	Medium	Medium

Specific risks (suggested by the checklist or otherwise identified)						**Treatment action**					**Post-Treatment residual risk scores**		
Objective	**Risk ID (OP code+nnn)**	**Comments/Potential mitigation**	**Risk description (cause/risk/effect)**	**Status**	**Project manager (surname, first name)**	**Action description**	**Project manager (surname, first name)**	**Probability**	**Impact**	**P x I**	**Probability**	**Cost**	**Time**
Efficient & attractive transport interchange	WLR -003	Perform a study of the cost impact and negotiate with Dulles Metrorail Project and NS. Present alternative means to achieve the desired safety goals.	Planning and approval risk	Open	Saran, Nikita	Early engagement with stakeholders	Saran, Nikita	3	3	9	High	Low	High
Minimal disruption to surrounding buildings	WLR -004	There is concern that current plans will cause problems in regards to the operation of the roundabout, traffic delay, and also bike/ped impacts. Traffic study is needed to assess the situation.	Existing building stability and settlement during construction and operation	Open	Saran, Nikita	Reducing vibration and noise through appropriate construction methods and in track-slab design	Saran, Nikita	3	3	9	High	Medium	Medium
Minimal disruption to surrounding buildings	WLR -005	permitting issue because the tracks will go over the stream. There was not a separate line item in the cost estimate, but the drainage line item was high enough to take into account this effort.	General noise during construction causing injunctions delaying works	Open	Saran, Nikita	Reducing vibration and noise through low vibration and noise installation methods	Saran, Nikita	3	2	6	Medium	Low	Very Low

Specific risks (suggested by the checklist or otherwise identified)						**Treatment action**					**Post-Treatment residual risk scores**		
Objective	**Risk ID (OP code+nnn)**	**Comments/Potential mitigation**	**Risk description (cause/risk/effect)**	**Status**	**Project manager (surname, first name)**	**Action description**	**Project manager (surname, first name)**	**Probability**	**Impact**	**P x I**	**Probability**	**Cost**	**Time**
Affordable good value for money scheme	WLR -006	Further evaluation is needed in the EIS/NEPA phase, and close coordination with the authorities that have jurisdiction will be needed. The cost of potential alternatives and the likelihood that an alternative alignment will need to be developed	Ground contamination risks due to works	Open	Saran, Nikita	Undertaking an environmental study of ground water and aquifers	Saran, Nikita	3	3	9	High	Very high	High
Affordable good value for money scheme	WLR -007	There is a limit in having RR put up job dedicated positions and a schedule of activities that can be adhered to. To have responsibility placed on the contractor for coordinating with the RRs for flaggers by specification	Stakeholder views cause disruption and delay.	Open	Saran, Nikita	Early engagement with stakeholders	Saran, Nikita	3	1	3	Low	Medium	High
Affordable good value for money scheme	WLR -008	Usually park-and-ride lots make for good construction staging areas as well as the maintenance yard and shop site. This is therefore a right-of-way acquisition issue. There is a need to monitor right-of-way acquisition so that a delay to the project is avoided.	Land acquisition strategy - local landowners	Open	Saran, Nikita	Early engagement with stakeholders	Saran, Nikita	3	2	6	Medium	Medium	High

Specific risks (suggested by the checklist or otherwise identified)						**Treatment action**					**Post-Treatment residual risk scores**		
Objective	**Risk ID (OP code+nnn)**	**Comments/Potential mitigation**	**Risk description (cause/risk/effect)**	**Status**	**Project manager (surname, first name)**	**Action description**	**Project manager (surname, first name)**	**Probability**	**Impact**	**P x I**	**Probability**	**Cost**	**Time**
Affordable good value for money scheme	WLR -009	Mitigate by defining the access restrictions in the contract specifications. A good public outreach plan during construction is also needed.	Land acquisition strategy -council land	Open	Saran, Nikita	Early engagement with stakeholders	Saran, Nikita	3	2	6	Medium	Medium	High
Affordable good value for money scheme	WLR -010	Traffic studies are needed in detail. Traffic studies need to take into account that the rail system is present.	Land acquisition strategy - National Trust	Open	Saran, Nikita	Early engagement with stakeholders	Saran, Nikita	3	3	9	High	Medium	High
Affordable good value for money scheme	WLR -011	Potentials for design refinement during EIS/PE. The grades have two 4% grades leading into and out of South Square Station (Alt. D-3), and that is not considered overly steep. Sharp curves have been used only when they are adjacent to stations to minimize impacts to streets and surroundings.	Confirmation of the ability to proceed with a signed off development agreement	Open	Saran, Nikita	Full engagement with the network rail	Saran, Nikita	3	2	6	Medium	Very high	Very High
Keep Windsor operational	WLR -012	Vertical curves do meet the absolute minimum curve lengths. Optimizing speed was an essential element in both the plan and profile. Potentials for design refinement during EIS/PE	Utility disruption / re-routing	Open	Saran, Nikita	Acquiring a detailed service study/report	Saran, Nikita	3	2	6	Medium	Very high	Medium

Specific risks (suggested by the checklist or otherwise identified)						**Treatment action**					**Post-Treatment residual risk scores**		
Objective	**Risk ID (OP code+nnn)**	**Comments/Potential mitigation**	**Risk description (cause/risk/effect)**	**Status**	**Project manager (surname, first name)**	**Action description**	**Project manager (surname, first name)**	**Probability**	**Impact**	**P x I**	**Probability**	**Cost**	**Time**
Affordable good value for money scheme	WLR -013	Potential for design refinement during EIS/PE. The locations are envisioned to be on the tangent sections in front of each end-of-line station.	Archaeology remains discovered.	Open	Saran, Nikita	Acquiring an archaeological baseline report.	Saran, Nikita	3	3	9	High	Medium	High
4tph between Slough and Waterloo, all stopping at Windsor	WLR -014	Potential for design refinement during EIS/PE has to be agreed. Assumed normal height structures have to be estimated so there should not be a cost impact.	The rolling stock assumptions are proven incorrect or not possible, requiring additional infrastructure interventions outside of the immediate WLR area (e.g. Waterloo).	Open	Saran, Nikita	Appropriate definition of the base case design envelope to exclude this	Saran, Nikita	3	3	9	High	Very high	Very High
4tph between Slough and Waterloo, all stopping at Windsor	WLR -015	Clearances will need to be checked.	The train specification proposed by Windsor Link for the Dulles Metrorail Project cannot operate on the infrastructure both within Windsor and beyond towards London.	Open	Saran, Nikita	Appropriate definition of the base case service to Staines and the train model at GRIP 3	Saran, Nikita	3	3	9	High	Very high	Very High
Affordable good value for money scheme	WLR -016	It is assumed that a 40-foot separation and use of crash walls will not both be required.	Risk of finding unexploded ordnance	Open	Saran, Nikita	Acquiring a UXO risk report/desk study	Saran, Nikita	3	3	9	High	Medium	Low

Specific risks (suggested by the checklist or otherwise identified)						**Treatment action**					**Post-Treatment residual risk scores**		
Objective	**Risk ID (OP code+nnn)**	**Comments/Potential mitigation**	**Risk description (cause/risk/effect)**	**Status**	**Project manager (surname, first name)**	**Action description**	**Project manager (surname, first name)**	**Probability**	**Impact**	**P x I**	**Probability**	**Cost**	**Time**
4tph between Slough and Waterloo, all stopping at Windsor	WLR -017	Stations need to be designed to budget, and amenities need to be prioritized. Bridge architectural treatments are low cost and included in cost estimate.	A single-track solution is adopted between the Thames River Crossing and east of Riverside Station with a passing at the new station that unacceptably limits the number of trains per hour.	Open	Saran, Nikita	A simple train model/ timetable analysis is required to evidence capacity.	Saran, Nikita	3	3	9	High	Very high	Very Low
A new single station for Windsor	WLR -018	Early lock-in of prices is essential.	The existing properties have basement structures within the highways being used for the new subsurface route.	Open	Saran, Nikita	A survey of all buildings is required to understand existing assets	Saran, Nikita	3	3	9	High	High	High
4tph between Slough and Waterloo, all stopping at Windsor	WLR -019	Track and bridge contractors in the construction packages have to be separated to achieve highly qualified, specialized contractors. Medium size contracts, $200M to $300M, attract qualified firms, yet keep bonding costs within most large contractors' reach.	A double track solution is required to achieve four trains per hour, and this is unaffordable or unacceptable for the project.	Open	Saran, Nikita	Timetable and comprehensive cost plan developed at GRIP 3	Saran, Nikita	3	3	9	Medium	Very high	Very High
Minimal disruption to surrounding buildings	WLR -020	This needs to be addressed in the detailed design. Roadway estimate unit prices reflect the degree of difficulty.	Concern over vibration levels for new developments, over the sub-surface length	Open	Saran, Nikita	Reducing vibration noise and motion through isolated track-slab design.	Saran, Nikita	3	2	6	Medium	High	Low

Specific risks (suggested by the checklist or otherwise identified)						**Treatment action**					**Post-Treatment residual risk scores**		
Objective	**Risk ID (OP code+nnn)**	**Comments/Potential mitigation**	**Risk description (cause/risk/effect)**	**Status**	**Project manager (surname, first name)**	**Action description**	**Project manager (surname, first name)**	**Probability**	**Impact**	**P x I**	**Probability**	**Cost**	**Time**
Efficient low maintenance railcar system	WLR -021	The Friday Center is currently grade separated for alternative C-1. Erwin St. analysis is needed, and it will be important to work with NCDOT and Duke University.	No room for error on design and build, as level requirements are very tight for tunnel gradients and radii.	Open	Saran, Nikita	Early GRIP 3 track design to ensure as much confidence is developed as possible	Saran, Nikita	3	3	9	High	Medium	Medium
Efficient low maintenance railcar system	WLR -022	Any pedestrian bridge at Alston Ave. would be necessitated by the introduction of a commuter rail station in the commuter rail project, and hence such cost would be part of that project. The VA Medical Center needs study in light of the fact that there is no pedestrian access to the west end of the Duke Medical Center Station.	Safety of passengers needing to disembark if a train breaks down within the sub-surface length	Open	Saran, Nikita	Provision of a safe cess walkway in the tunnel	Saran, Nikita	2	3	6	Medium	Medium	Low

Specific risks (suggested by the checklist or otherwise identified)						**Treatment action**					**Post-Treatment residual risk scores**		
Objective	**Risk ID (OP code+nnn)**	**Comments/Potential mitigation**	**Risk description (cause/risk/effect)**	**Status**	**Project manager (surname, first name)**	**Action description**	**Project manager (surname, first name)**	**Probability**	**Impact**	**P x I**	**Probability**	**Cost**	**Time**
Keep Windsor operational	WLR -023	Risk has to be scheduled in regards to the ROMF and station locations. There should be sufficient time to acquire any zoning change during the final design phase. It does become an issue if the preferred ROMF location changes after the determination of the site at the conclusion of the EIS phase.	Disruption to local economy during implementation	Open	Saran, Nikita	Limiting road closures where possible and employing good TM management providing advanced notice to drivers and businesses	Saran, Nikita	3	3	9	High	Low	Very Low
Keep Windsor operational	WLR -024	Potentials for design refinement during EIS/PE	Disruption to the existing Dulles Metrorail Project during construction	Open	Saran, Nikita	Aiming to keep the current Dulles Metrorail Project operational for as long as possible during construction works	Saran, Nikita	2	2	4	Low	Low	Very Low
Keep Windsor operational	WLR -025	ROMF sites with significant issues will not be chosen.	Disruption to the existing foot and cycle traffic during construction	Open	Saran, Nikita	Providing alternative safe walking and cycling routes	Saran, Nikita	3	3	9	Very high	Very low	Very Low
Keep Windsor operational	WLR -026	Wetland issues will be studied in the EIS process, and wetland impacts will be budgeted.	State visits and funerals are carried out without notice, and work needs to be flexible.	Open	Saran, Nikita	Understanding the typical scenario and including it within the construction phasing	Saran, Nikita	3	2	6	Medium	Very low	Very Low

Specific risks (suggested by the checklist or otherwise identified)						**Treatment action**					**Post-Treatment residual risk scores**		
Objective	**Risk ID (OP code+nnn)**	**Comments/Potential mitigation**	**Risk description (cause/risk/effect)**	**Status**	**Project manager (surname, first name)**	**Action description**	**Project manager (surname, first name)**	**Probability**	**Impact**	**P x I**	**Probability**	**Cost**	**Time**
4tph between Slough and Waterloo, all stopping at Windsor	WLR -027	Poor soils from previous plans were already identified. This information was proportioned into the rest of the alignment. This risk is for exceeding those allowances.	Franchise process fails to include for WLR proposals	Open	Saran, Nikita	Early engagement with DFT regarding the new franchise	Saran, Nikita	2	2	4	Low	Medium	Very Low
A new single station for Windsor	WLR -028	Rock is known to be along the Dulles Metrorail Project ROW and Alston area, and the lack of blasting ability is a constraint. Borings should identify.	New platforms should not be on a curved track of less than a 1000m radius. WLR is potentially 300m.	Open	Saran, Nikita	Developing GRIP2 to maximize the straightest possible platform length	Saran, Nikita	3	3	9	High	Low	Low
A new single station for Windsor	WLR -029	Line item allowance has been incorporated. RR contamination is usually rather shallow.	Track speed causes high cant values that are inappropriate for platforms	Open	Saran, Nikita	Limiting track speed whilst keeping 4tph and all trains stopping	Saran, Nikita	3	2	3	Low	Very low	Very Low
Efficient low maintenance railcar system	WLR -030	EIS will reveal these needs, and a conservative allowance is included in the current costs and schedule.	Track speed causes high cant values that are inappropriate for switches	Open	Saran, Nikita	Developing GRIP2 to ensure track systems are functional	Saran, Nikita	2	2	4	Low	Very low	Very Low
Efficient low maintenance railcar system	WLR -031	This is evident in the conceptual plans, and this has been accounted for in the estimate. Complications may arise in regards to the interface of the station.	Gradients cause wheel slippage when combined with a tight radius.	Open	Saran, Nikita	Developing GRIP2 to ensure rolling stocks are functional	Saran, Nikita	3	2	6	Medium	Low	Very Low

Specific risks (suggested by the checklist or otherwise identified)						**Treatment action**					**Post-Treatment residual risk scores**		
Objective	**Risk ID (OP code+nnn)**	**Comments/Potential mitigation**	**Risk description (cause/risk/effect)**	**Status**	**Project manager (surname, first name)**	**Action description**	**Project manager (surname, first name)**	**Probability**	**Impact**	**P x I**	**Probability**	**Cost**	**Time**
Efficient low maintenance railcar system	WLR -032	Existing costs and schedule have significant contingencies for utility relocation. Due diligence will involve early identification of utilities in need of relocation and effective coordination with utility owners during design. An aggressive subsurface utility investigation is warranted.	Unrecoverable broken-down trains within the tunnel due to gradient	Open	Saran, Nikita	Ensuring the capacity of existing rolling stocks to push broken-down trains out	Saran, Nikita	3	2	6	Medium	Very low	Very Low
Efficient low maintenance railcar system	WLR -033	More will be known after the EIS, no specific allowance in budget for archeological finds, since the area has few occurrences.	The migration of curves at the bottom of the ramp approaches the switch.	Open	Saran, Nikita	The use of track slab will prevent track profile changes.	Saran, Nikita	2	2	4	Low	Medium	Low
4tph between Slough and Waterloo, all stopping at Windsor	WLR -034	The track slab	The capacity of the existing track outside of the immediate WLR area cannot support four trains per hour.	Open	Saran, Nikita	Appropriate definition of the base case service to Waterloo and the train model at GRIP 3	Saran, Nikita	3	2	6	Medium	Very high	Very High
Affordable good value for money scheme	WLR -035	An allowance is contained in the cost estimate.	A substantial upgrade to the signaling system is required.	Open	Saran, Nikita	Required review at GRIP 3	Saran, Nikita	3	3	9	High	High	High
Affordable good value for money scheme	WLR -036	These shall be identified through EIS. Effective side treatment to aerial structures helps to mitigate impact.	A substantial upgrade to the power system is required.	Open	Saran, Nikita	Required review at GRIP 3	Saran, Nikita	3	3	9	High	High	High

Specific risks (suggested by the checklist or otherwise identified)						**Treatment action**					**Post-Treatment residual risk scores**		
Objective	**Risk ID (OP code+nnn)**	**Comments/Potential mitigation**	**Risk description (cause/risk/effect)**	**Status**	**Project manager (surname, first name)**	**Action description**	**Project manager (surname, first name)**	**Probability**	**Impact**	**P x I**	**Probability**	**Cost**	**Time**
Affordable good value for money scheme	WLR -037	This is known. The elevation change is dramatic.	Thames River Crossing is the oldest iron rail bridge in operation and has listed a building status.	Open	Saran, Nikita	Maintained single track operation	Saran, Nikita	3	3	9	High	Very low	Very Low
Minimal disruption to surrounding buildings	WLR -038	The AA option provides a conservative estimate. Development has to be designed to refine the option alternatives.	Risk of "harm" to listed buildings	Open	Saran, Nikita	Care taken in design to avoid unnecessary impacts	Saran, Nikita	3	3	9	High	High	High
Affordable good value for money scheme	WLR -039	This is the current plan; hence, this is a known risk and has been budgeted for.	Existing unknown sub-surface tunnels, culverts, and features on the route	Open	Saran, Nikita	GPR to be undertaken as a part of a detailed survey at GRIP 3	Saran, Nikita	3	3	9	High	High	High
Affordable good value for money scheme	WLR -040	The design is to have the rail profile at 15-501; hence, any retaining wall would be on the east side of the LRT tracks away from 15- 501. This is how the profile was done. Also, the property to the east is the existing Pepsi plant. This will most likely be redeveloped by the Jewish community, and TTA will continue to work with a developer or with the owner.	The criticality of further investigation and design work is not understood at senior level within WLR.	Open	Saran, Nikita	Full engagement with the network rail by the WLR directors	Saran, Nikita	3	3	9	High	Medium	Low

Specific risks (suggested by the checklist or otherwise identified)						**Treatment action**					**Post-Treatment residual risk scores**		
Objective	**Risk ID (OP code+nnn)**	**Comments/Potential mitigation**	**Risk description (cause/risk/effect)**	**Status**	**Project manager (surname, first name)**	**Action description**	**Project manager (surname, first name)**	**Probability**	**Impact**	**P x I**	**Probability**	**Cost**	**Time**
4tph between Slough and Waterloo, all stopping at Windsor	WLR -041	Design refinement during PE.	The track bed width from Windsor to Slough is no longer suitable for twin tracking to satisfy the timetable.	Open	Saran, Nikita	Full asset inspections and surveys undertaken at the start of GRIP 3 and reviewed	Saran, Nikita	2	2	4	Low	High	High
Affordable good value for money scheme	WLR -042	Structured parking in the revised estimate	The risk to the business case is proceeding to GRIP 3 without detailed civil asset information from the network rail and understanding of the assets to be used in WLR.	Open	Saran, Nikita	Full asset inspections and surveys undertaken at the start of GRIP 3 and reviewed	Saran, Nikita	3	2	6	Medium	High	High
Affordable good value for money scheme	WLR -043	The budget should be conservative enough that the overrun risk is minor.	The risk to the business case is proceeding to GRIP 3 without detailed signaling asset information from the network rail and understanding of the assets to be used in WLR.	Open	Saran, Nikita	Full asset inspections and surveys undertaken at the start of GRIP 3 and reviewed	Saran, Nikita	2	2	4	Low	High	High
Affordable good value for money scheme	WLR -044	This has been accounted for in the estimate.	The risk to the business case is proceeding to GRIP 3 without detailed traction power asset information from the network rail and understanding of the assets to be used in WLR.	Open	Saran, Nikita	Full asset inspections and surveys undertaken at the start of GRIP 3 and reviewed	Saran, Nikita	3	2	6	Medium	High	High

Specific risks (suggested by the checklist or otherwise identified)						**Treatment action**					**Post-Treatment residual risk scores**		
Objective	**Risk ID (OP code+nnn)**	**Comments/Potential mitigation**	**Risk description (cause/risk/effect)**	**Status**	**Project manager (surname, first name)**	**Action description**	**Project manager (surname, first name)**	**Probability**	**Impact**	**P x I**	**Probability**	**Cost**	**Time**
Safe transport system	WLR -045	This has now been accounted for in the revised estimate.	The existing level crossing represents an unacceptable risk to WLR and needs to be closed.	Open	Saran, Nikita	The new franchise requires 4tph through the same level crossings	Saran, Nikita	3	2	6	Medium	High	High
Affordable good value for money scheme	WLR -046	Procure real estate in accordance with the real estate acquisition management plan and project schedule.	The risk that forecasts increase in patronage will be insufficient to deliver adequate revenue to satisfy the business case.	Open	Saran, Nikita	Detailed discussions with DFT required to agree funding	Saran, Nikita	3	3	9	High	High	High
Affordable good value for money scheme	WLR -047	The EIS will need to have more clarification on the issue. Federal funds cannot be used in 100-year floodplain areas.	The risk of new franchise improvements to 4tph to Windsor removing large patronage growth upon which WLR relies for funding	Open	Saran, Nikita	Detailed discussions with DFT required to agree funding	Saran, Nikita	3	2	6	Medium	High	High
Affordable good value for money scheme	WLR -048	Risks will be lessened if there is an agreement locking in plans early in the process that holds continuity through administration changes. Key issues have been the total width of the new street, traffic flow, bicycle accommodations, and crossing safety.	The risk of combining complex projects into a single program causing undue risk within a small town	Open	Saran, Nikita	Careful phasing and appropriate solutions prioritized in the GRIP 3 options	Saran, Nikita	3	2	6	Medium	Medium	High
Affordable good value for money scheme	WLR -049	This will be covered in an agreement.	Platform lengthening uncovers unknown cables and sub-surface features.	Open	Saran, Nikita	Full asset inspections and surveys undertaken at the start of GRIP 3 and reviewed	Saran, Nikita	3	2	6	Medium	High	Medium

Specific risks (suggested by the checklist or otherwise identified)						**Treatment action**					**Post-Treatment residual risk scores**		
Objective	**Risk ID (OP code+nnn)**	**Comments/Potential mitigation**	**Risk description (cause/risk/effect)**	**Status**	**Project manager (surname, first name)**	**Action description**	**Project manager (surname, first name)**	**Probability**	**Impact**	**P x I**	**Probability**	**Cost**	**Time**
Affordable good value for money scheme	WLR -050	Typical design and traffic construction maintenance are included in the estimate. Specifications need to spell out the maintaining access to businesses. There are few businesses on the route though.	Resources are not available to meet the design program in specialized areas.	Open	Saran, Nikita	Appropriate allocation of resources through a competent design chain	Saran, Nikita	3	3	9	High	Low	Low
Efficient low maintenance railcar system	WLR -051	Early identification of park-and-ride lots and TPSS locations is needed.	Resources not available to meet the construction program in specialized areas	Open	Saran, Nikita	Appropriate allocation of resources through a competent design chain	Saran, Nikita	3	3	9	High	Low	Low
Efficient low maintenance railcar system	WLR -052	The new alignment is not likely to be required, but if so, it would be costly.	New rolling stock requirements required to deliver the objectives present prohibitive costs to WLR.	Open	Saran, Nikita	Selection of solutions that use existing rolling stocks from new franchises or modest interventions	Saran, Nikita	3	3	9	High	Very high	Very High
Safe transport system	WLR -053	Hill has been integral with the development of the alignment in the LPA.	Electrification using third rail solution is not acceptable to ORR, requiring alternative solutions for traction power.	Open	Saran, Nikita	Detailed discussions and risk assessments with ORR required to agree the extension of the third rail system	Saran, Nikita	2	2	4	Low	High	Medium
Keeping Windsor operational before, during, and after construction	WLR -054	It is necessary that it is within the city ROW or a transit easement.	Local groundwater flooding caused by the impermeability of sub-surface solutions affecting hydrology in the area	Open	Saran, Nikita	GRIP 3 study to be undertaken to confirm that sub-surface water flows and mitigations required for Windsor	Saran, Nikita	3	2	6	Medium	High	Medium

4.8.8. Risk Response Planning

Each risk will be assigned to a project team member for monitoring purposes to ensure that the risk is adequately and timely managed and/or addressed. For each risk that will be mitigated, the project team will identify ways to perform risk monitoring, controlling, and reporting throughout the project lifecycle. Appropriate options and action plans will be developed to reduce the threats of specific risks to project objectives and/or take advantage of possible opportunities. All project change requests will be analyzed for their possible impact to project risks. The risk register will be continuously updated with a specified proposed response plan for the occurrence of each risk event and an updated project management plan.

4.8.9. Risk Monitoring and Control

Risk monitoring and control is the process of identifying, analyzing, and planning for newly identified risks, monitoring previously identified risks, and re-evaluating existing risks to verify the planned risk response strategies for their effectiveness. The level of risk on a project will be tracked, monitored, and reported throughout the project lifecycle. The updated status risk register list will be maintained by the project team and will be reported as a component of the project status reporting process in a weekly basis.

Project activities involved in risk monitoring and control will include the following:

- Validating risk mitigation strategies and alternatives
- Taking corrective action when actual events occur
- Assessing the impact of actions taken (cost, time, and resources) on the project
- Identifying new risks resulting from risk mitigation actions
- Ensuring that the project plan (including the risk management plan) is maintained
- Ensuring change control addresses risks associated with the proposed change

- Revising risk management documents to capture the results of mitigation actions
- Updating the risk register
- Communicating the risk management status and risk response follow-through as appropriate
- Establishing communication as appropriate

4.8.10. Risk Management Closeout

In the Dulles Metrorail Corridor Project success, the transition of any open risks and lessons learned is important for project maintenance, support, and future project work.

The following risk management activities are applied:

- Validation of the completion of identified risks
- Documenting the remaining open risks and providing access to the final report
- Producing final risk management metrics and evaluating the process effectiveness against the established benchmarks
- Capturing risk factors and risk mitigation plans for inclusion in risk reference models (lessons learned)

4.8.11. Sponsor Acceptance

Signing the acceptance letter is to hereby acknowledge that they have reviewed and approved the risk management plan for the Dulles Metrorail Corridor Project. Any changes to this procurement management plan will be coordinated with and approved by the undersigned or their designated representatives.

Chart 51. *Risk Management Plan members*

Approver name	Title	Signature	Date
Dheemanth Rajkumar	Project Sponsor		
Nikita Saran	Project Manager		

Revision History				
Version	**Date**		**Reason**	**Executive sponsor sign off**

4.9. Procurement Management Plan

4.9.1. Introduction

The procurement management process for the Dulles Metrorail Corridor Project utilizes the stages of plan procurement management, conduct procurement, and control procurement. The plan provides the identification of the requisite items, types of contracts, and contract approval process and takes into consideration procurement risks and constraints.

4.9.2. Procurement Management Approach

The proposed construction activities of the Dulles Metrorail Corridor Project are:

Among the world's most sophisticated rail systems, and they boast the latest safety features, such as advanced control systems. Passengers can expect one of the smoothest train rides ever experienced as a result of innovative design and construction. Phase includes five stations, 6 miles (nearly 10 kilometers) of elevated track, and twin tunnels running beneath one of the busiest office and retail centers in the United States—where 700,000 cars travel each day. Construction required three enormous overhead cranes custom-built to lift segments of elevated guideway into place between huge piers. One of the 366-ton behemoths—heavier than a fully loaded Airbus A350—stretched across 12 lanes of traffic over the Capital Beltway. A total of 3 miles (nearly 3 kilometers) of the Phase alignment comprises aerial track,

including both the inbound and outbound guideway. (Bechtel Corporation , n.d.c, para. 3-4)

The project manager has the overall responsibility for the procurement of the project items with the support of the procurement manager. The project manager may delegate specific responsibilities to project team members to ensure that all items were procured for the successful completion of the project. The project manager will work with the project team, contracts/purchasing department, and other key players to manage the procurement activities from their initiation to their closing.

4.8.3. Procurement Definition

The project activities are to be performed by few contractors, since most of the construction execution will be performed by a general contractor through a fixed fee contract. The procurement items were defined by the project manager with the support of the project team, project designer, and procurement manager in the following table.

Chart 52. *Procurement Details*

Item	Purpose/Justification
Bechtel Corporation staff	Bechtel Corporation staff is responsible for material acquisition, equipment sourcing, remote connectivity testing, and remote network monitoring.
Bechtel Corporation ASPs (authorized service providers)	ASPs are responsible for all rigging duties, on site configurations, drive testing and final onsite network tweaking, providing daily updates, and ensuring compliance with.
FLOW ASP/Contractors	Flow contractors are responsible for providing the required electrical and transmission connectivity, project material storage, timely delivery to sites, and waste material removal from sites for disposal.
Field service operations	To inspect and ensure compliance with codes and design and provide daily updates

All other services related to project management will be supported by regular Bechtel Corporation employees, which are hourly compensated.

4.9.4. Types of Contracts

The Dulles Metrorail Corridor construction is a project with a different scope from normal Bechtel Corporation project activities. The project is a public contract monitored and handled by the Metropolitan Washington Airports Authority (MWAA). The project is said to rank as one of the largest construction projects in the United States.

Inspectors carry up-to-date certifications for the work they are verifying, including certifications issued by the American Concrete Institute (ACI), Washington Area Council Engineering Laboratories (WACEL), Virginia Department of Transportation (VDOT), American Welding Society (AWS), and National Institute for Certification in Engineering Technologies (NICET). Dulles Metrorail Corridor construction inspectors hold certifications for soil compaction testing, concrete testing, structural steel weld inspections, protective coatings, roofing, waterproofing, and asphalt testing, to name just a few.

The Dulles Metrorail Corridor Project marks the first use in the United States of technology co-developed by Bechtel that enabled secure, two-way communication and data exchange between surveyors and satellite office staff and GPS-guided construction machinery, which greatly enhanced construction productivity and quality.

This makes it critical to ensure having an expert contractor and designer as part of the project collaborative team. There is abundant data and documentation that supports the requirements needed to ensure an appropriate procurement process. Since the project activities are well defined, a firm-fixed price contract will be granted to a general contractor. Based on this contract type, the general contractor will include all equipment, material, labor, cleaning, and waste disposal.

Required additional services, such as permitting expert services and inspection services, are to be contracted by the hour of service provided, with a fixed maximum number of hours approved for working. The project management, site engineering, civil works, installation, product configuration, and integration capabilities cover end-to-end deployments from site acquisition to customer acceptance. Any modification to the service hours included in the service contracts

is to be evaluated by the project manager through the change control process and approved before any service can start.

4.9.5. Procurement Cost Determination

The project manager will issue a request for quote (RFQ) to request proposals from vendors that can provide the services and materials required by the project. The vendors will outline in their proposal in a breakdown of costs and include how the work will be accomplished, who will perform the work, and proof of their experience. Proposals that omit solicited information or contain incomplete information will be discarded from consideration. Costs are almost always used as part of the procurement decision criteria, but in this case, experience in this type of project will be a priority.

4.9.6. Procurement Risks and Constraints

The Dulles Metrorail Corridor Project is critical, since the project is a public contract monitored and handled by the Metropolitan Washington Airports Authority (MWAA). The project is said to rank as one of the largest construction projects in the United States.

The general contractor, under a fixed fee contract, will be responsible for 90% of activities required for the project execution and success. Risks and uncertainties regarding the vendors are to be analyzed and managed in order to ensure project continuity in case of vendor failure to comply with contract requirements. Every effort must be made to identify all constraints prior to any project or procurement planning, as constraints identified later in the project lifecycle can significantly impact the project's likelihood of success.

Even though all project risks are included in the risk register as part of the risk management plan, specific risks and uncertainties regarding procurements are summarized in the table below to ensure keeping them accessible. The ASPs outline their breakdowns in their proposals, including the methodology for completing the assignments, who will perform the job, and their relevant experience. Proposals that omit solicited information or contain incomplete details will be discarded from

deliberations. Costs are used as part of the decision criteria; however, experience in this type of project will be considered a priority.

Chart 53. *Procurement Constraints and Risks*

Risks
Failure to comply with material specifications
Failure to comply with approved drawings, construction materials, and mandatory instructions and guidelines.
Missing trainings and/or expertise
Failure to provide necessary equipment
Safety issues
Environmental incidents
Failure to comply with scheduled tasks

4.9.7. The Contract Approval Process

All ASP (authorized service providers) proposals are received in an open and transparent bidding process. The project and procurement managers are responsible for managing the bidding process. All procurement management transactions are executed within the Bechtel Corporation Code of Business Ethics; this ensures business responsibility and reminds everyone that every action counts.

4.9.8. Decision Criteria

The project manager, cost control experts, procurement manager, legal authority, and designated project members meet to evaluate proposals and grant the contracts.

4.9.9. Control Procurement

All decisions and documents regarding procurement are subject to an audit process and are stored electronically in the project SharePoint in the corresponding file.

As part of the contract, ASPs (authorized service providers) are required to accede to the conditions, restrictions, penalties, internal processes, and standards that are required during project execution.

The field engineers and FSO (Foreign Service Officer) staff will perform ASP evaluations, providing status updates to the PM and team at the end of the day. The

PM maintains an ASP competency log that is updated weekly as part of the project metrics.

Each metric is rated on a 1-3 scale and a computed transactional efficiency calculation.

Chart 54. ASP Competency Log

ASP	Product quality	Punctuality	Documentation quality	Development costs	Costs/ Unit	Transactional efficiency
ASP-1						
ASP-2						

Key: 1-Unsatisfactory, 2-Acceptable, and 3-Exceptional

ASPs with an efficiency result of less than 75% will be informed officially of their questionable status (email and phone call), which obliges the ASP to respond with a written justification of the present status, a mitigation proposal, and a commitment plan to comply with the efficiency performance within 3 days.

If the ASP fails to comply with the stipulations, this will trigger the cancellation of the vendor's ASP status. Vendors with an efficiency result of less than 85% will enter in a probatory process. The probatory process obliges the vendor to provide a written justification of his problems, a mitigation plan, and a commitment to comply with the efficiency performance within 7 days. Failure to comply with the requirements defined will automatically trigger their contract and payments' cancellation.

4.9.10. ASP (Authorized Service Providers) Management

The Bechtel Corporation procurement department provides supervision and assistance regarding purchasing and contracting; however, the project manager has the accountability and responsibility for the ASP project performance.

4.9.11. Sponsor Acceptance

The project sponsor and project manager approve the procurement plan after careful review. Alterations or adjustments may be done after the collaboration with the undersigned or their designated representatives.

Chart 55. *Procurement Management Plan members*

Approver name	Title	Signature	Date
Dheemanth Rajkumar	Project Sponsor		
Nikita Saran	Project Manager		

Revision History				
Version	**Date**		**Reason**	**Executive sponsor sign off**

4.10. Stakeholder Management Plan

4.10.1. Introduction

The Airports Authority will conduct an evaluation of the project and initiate the development and implementation of a stakeholder management plan. The FTA is not involved in the stakeholder management assessment. Bechtel Corporation will manage the stakeholder management as part of its project oversight and work with the Airports Authority to develop a mutually agreed upon project execution strategy that contains a description of the required stakeholder management process.

In the Dulles Metrorail Corridor Project stakeholder management plan, the approach to manage project stakeholders, stakeholder management roles and responsibilities, stakeholder identification, stakeholder analysis, and stakeholder management strategies is identified, based on PMBOK guidelines.

4.10.2. Approach

The constraints of time, cost, and scope are essential for this project, requiring strategic communication throughout the project cycle. The project team will update and review the stakeholder registry when necessary to guarantee a motivated collaborator management strategy ensuring the engagement and satisfaction from all those involved.

4.10.3. Roles and Responsibilities

The stakeholder roles and their duties are summarized in the table below:

Chart 56. *Roles and Responsibilities*

Stakeholder (Role)	Responsibilities
Project manager	• To initiate effort to develop the stakeholder management plan • To guide initial stakeholder analysis • To complete the stakeholder management plan • To manage the schedule and activities related to stakeholder communication and engagement
Sponsor	• To identify stakeholders • To provide input into the categorization of stakeholders • To provide advice in preparation strategies to be included in the stakeholder management plan • To approve the stakeholder management plan • To play a lead role in representing the project to external stakeholders
Project team	• To provide advice and review the stakeholder management plan • To assist in the identification and classification of stakeholders • To assist in the development of management strategies • To provide information to support stakeholder communication
Government agencies	• They will communicate any condition or requirement to the project and community, if necessary. • To always ensure environmental and community safety
Design firm	• To provide information to support stakeholder communication • To ensure frequent and effective communication towards project issues
Construction company	• To provide information to support stakeholder communication • To ensure frequent and effective communication towards project issues

4.10.4. Stakeholder Management Processes

The project manager and his project team will perform the stakeholder identification and analysis to define the corresponding management strategies. This process will provide the required information to manage stakeholders for the entire project lifecycle.

4.10.5. Stakeholder Identification

A stakeholder register resulted as the output of the stakeholder management processes, which included several aspects, such as the influence levels of each stakeholder in the project, people who are affected by the project work, and their interests.

4.10.6. Stakeholder Analysis

The stakeholder analysis was prepared with the use of existing project documentation, such as the project charter, brainstorming techniques, and meetings. Determining the stakeholder influence and impact started since the initial project phases, but it was extended until project completion.

Chart 57. *Table Stakeholder Analysis*

Stakeholder group	Involvement in the project	Problems, needs, and interest	Potentials
Project manager	• He coordinates all deliverables and negotiates contracts with vendors. • The project manager reports progress and risks to the sponsor. • He is responsible for the overall project planning and execution. • The project manager is authorized by the sponsor to perform all logistics required for the execution of the project.	Interest on the project success	Knowledge and experience
Sponsor	• Approval of the project charter and all deliverables	Interest on the project success	Financial support
Project team	• The project team prepares all required documentation. • The project team executes the required tasks to achieve project deliverables.	Interest on the project success	Knowledge and experience
Government agencies	• Government agencies provide general requirements and conditions necessary for the viability of project. • They approve permits/endorsements. • They inspect/evaluate the project execution.	They will provide support if regulation and permitting processes are followed correctly.	Their approval is critical for the project execution.
Design firm	• The design firm will be responsible for preparing a design in accordance with construction codes and environmental regulations.	Interest on the project success and compliance	Knowledge and experience
Construction company	• It will be responsible for constructing in accordance with drawings and specs and on time and within budget.	Interest on the project success	Knowledge and experience
Nearby community	• It will be alert to any incompliance or project effect into its land or environment.	Interest on the project success within compliance	It shall be kept communicated to avoid misunderstandings and/or obstruction.

Stakeholders can generally be categorized into four possible areas:

Chart 58. *Influence Impact Matrix Classification*

	High impact	**Low impact**
High influence	**A.** Manage closely, keep informed, and solicit ongoing input and participation.	**B.** Keep informed and meet their needs.
Low influence	**C.** Manage, but less closely; periodically keep informed; and solicit input.	**D.** Monitor periodically.

The stakeholders typically most critical to project success are in category A, the high influence/high impact group. All results obtained from the analysis, with the use of expert judgment and brainstorming techniques, are to be incorporated in the stakeholder registry.

Chart 59. *Project Stakeholder Registry*

ID	Stakeholders	Roles - Responsibilities	Main expectations	Major requirements	Influence/Impact (as referred in Table 50)
1	Dheemanth Rajkumar	Sponsor	The project is to be completed on time and on schedule and 100% in compliance with standards.	No conflicts with the community are allowed. He must be kept informed of the project progress in a frequent basis.	A
2	Project team (administrative)	Subject matter expert	To support the project manager as required to obtain project success	Tasks are to be clearly communicated to ensure they are completed as expected.	A
3	Project team (field engineers)	Subject matter expert	To ensure the project is executed as per design and within budget and schedule	Tasks are to be clearly communicated to ensure they are completed as expected.	A
4	Workers (construction)	Construction workers	To have the expertise and commitment to complete the works on time and on schedule with the corresponding safety and regulatory assurances	Expectations and responsibilities are to be clearly communicated to ensure they are completed as expected.	D
5	Government agencies	Government representation	To represent the government and community and environmental interests	An evaluation of all regulations and conditions is to be performed prior to starting the project.	B
6	Inspector	Subject matter expert	To certify that the project is executed in accordance with codes and regulations	Tasks are to be clearly communicated to ensure they are completed as expected. Drawings and specifications are to be provided in advance.	C
7	Project design engineer	Subject matter expert	Construction design as required considering codes and regulations for the project success	The project design must overcome flooding risks.	A

ID	Stakeholders	Roles - Responsibilities	Main expectations	Major requirements	Influence/Impact (as referred in Table 50)
8	Employees	Site employees	The project is executed in accordance with codes and regulations and does not affect employees in any way.	Communication in regard to project processes is to be open.	B
9	Material suppliers	Suppliers	To provide the materials as expected (times and specs)	To receive detailed material specs in time to ensure availability and quality	D
10	Contractors	Contractors	Fair bidding processes	Fair bidding processes	B
11	Engineering project team	Subject matter experts (IT, RF, core network, and R.A.N.)	To ensure the project is executed as per the project specific design and compliance laws, within schedule and budget	Tasks are communicated in an elucidative manner and are completed as expected.	A

4.10.7. Stakeholder Management Strategies

Documenting the communication interest, message, channel, and frequency for each stakeholder will ensure that everything is communicated, understood, and attended as planned. Refer to the communication management plan for recommended communication channels and frequencies.

4.10.8. Execution of Management Strategies

This stakeholder management plan shall be reviewed in the following cases:

- When there are events scheduled to provide information for stakeholders
- When there are tasks related to the preparation and review of materials to support the events and other communication activities
- When there is a need for capturing input gathered from stakeholders
- When there is a need to follow-up to assess incorporating the input into the project execution
- Others, as applicable

4.10.9. Sponsor Acceptance

By signing the document, the undersigned acknowledge that they have reviewed and approved the stakeholder management plan for the Dulles Metrorail Corridor Project. Changes to this procurement management plan will be coordinated with and approved by the undersigned or their designated representatives.

Chart 60. *Stakeholder Management Plan members*

Approver name	Title	Signature	Date
Dheemanth Rajkumar	Project Sponsor		
Nikita Saran	Project Manager		

Revision History				
Version	**Date**		**Reason**	**Executive sponsor sign off**

CHAPTER V. CONCLUSIONS

Bechtel Infrastructure Inc. was founded in the year 1898. The company is focused on delivering world-class customer experience and has completed more than 25,000 projects in 160 countries on all seven continents. It has created jobs, grown economies, improved the resiliency of the world's infrastructure, increased access to energy, resources, and vital services, and made the world a safer, cleaner place. Bechtel Infrastructure has thoroughly reviewed and constantly updates risks and uncertainties to the program to identify “scope creeps,” schedule slippage, and cost increases. Aggressive risk assessment and change management is paramount to success. Effective communication with affected communities and agencies to ensure minimal impact to the existing local transportation network, the local commercial economy, and the social fabric of the community. Bechtel Infrastructure Inc provides full transparency in the procedures to be executed in the construction of the Dulles Corridor Metrorail Project along with the DTP (Dulles Transit Partners) and aims to complete the work and accounts for progression through the life of the contract. The lack of a project management methodology application to the Dulles Corridor Metrorail Project has been the reason for their projects’ delay, due to the lack of project monioring, control, and accountability.

> The Dulles Corridor Metrorail is among the world's most sophisticated rail systems and boasts the latest safety features, such as advanced control systems. Passengers can expect one of the smoothest train rides ever experienced as a result of innovative design and construction. This construction includes five stations, 6 miles (nearly 10 kilometers) of elevated track, and twin tunnels running beneath one of the busiest office and retail centers in the United States—where 700,000 cars travel each day. … Bechtel Corporation employed more than 2,000 people, most of them from the Washington, D.C., area, and contracted with more than 200 local businesses over the course of the project. (Bechtel Corporation, n.d.c. para. 3)

This project management plan was created using the analytical research method and the 6th edition of the PMBOK® Guide (PMI, 2017) and is intended to be the main source of comprehensive information for improving the overall project performance success rate and protecting their competitive advantages as promoted by Bechtel Corporation. Based on the current project circumstances, the most relevant points resulting from this project management plan were summarized as follows:

- The project charter creation gives Bechtel Corporation and its stakeholders a formal way to be able to share a common understanding of why the project is being done, the timeframe, deliverables, risks, assumptions, boundaries, and responsibilities, and since it is approved by the sponsor, it provides the project the importance that it requires to be managed and executed successfully. Leveraging experience, best practices, and lessons learned, also included in the integration management plan, will support Bechtel's management overview to cut costs and sidestep risks in the projects, enabling them to implement stronger project management practices for the future. This scope management plan exemplifies Bechtel Corporation's vast experience regarding scope change processes, requirements, limitations, and the accountability of the project manager and sponsor regarding any change approval.
- Trying to introduce any type of structure or control in an organization or environment that has been deficient of controls, such as in the Bechtel Corporation case, can appear as a significant challenge. Poorly managed change control has a negative influence on the customer's expectations, cost variances, schedule variances, team morale, resource management, and so on. They are inseparable from the perceptions of a project's success. This scope management plan will provide Bechtel Corporation significant guidance towards the scope change process, requirements,

limitations, and the accountability of the project manager and sponsor towards any change approval.

- Since this project is time sensitive, critical path activities and the schedule cost baseline determination are two major advantages of the schedule management plan. Bechtel Corporation will be able to measure the project's progress against a formal base to ensure keeping track and managing it in a controlled way through the project lifecycle.
- A major benefit resulting from the cost management plan was the identification of a cost baseline. Bechtel Corporation will be able to measure and report the project's progress against a formal base to ensure keeping track and managing it in a controlled way through the project lifecycle.
- The way to get the most value out of a project management methodology is through metrics tied to business goals, collecting the data, and making it available to everyone. The quality management plan provides Bechtel Corporation the guidance for keeping the project on track, extending those metrics across the project team and out to suppliers, contractors, the client, and stakeholders.
- One of the biggest challenges for Bechtel Corporation was "Project expense", which has forever been associated with their resource limitation, since they share resources with the projects related to capital generation. The resource management plan provides Bechtel Corporation the way to better allocate and organize the resources needed when they are needed and to justify the additional allocation of funds for additional resources to assist in the project, if necessary. Bechtel Corporation adheres to the labor standards, such as the freedom of association, forced labor avoidance, fair employment conditions, and elimination of discrimination, and contributes to the sustainable development of society and anti corruption. Bechtel Corporation requires the suppliers and its subcontractors to comply with the code of conduct. The Dulles Metrorail Corridor Project was

part of a larger regional project. Therefore, it was important that proper human resource management be in effect to boost the performance of the project team. The teams' competencies were recognized and utilized to organize and evaluate their performance.

- The payoff from investing time, money, and resources into Bechtel Corporation expense projects will be justified with the controlled and monitored results to be obtained in the regular occurring meetings included in the communication management plan. Those regular meetings will also develop the innovation within the team, since they will be able to have forums to provide solutions and ideas that will lead to increased productivity, profitability, and project success. The project communication plan assisted in keeping the project on track, within budget, and aligned with Bechtel Corporation's expectations by annotating who would be communicated with whom, when, and how. The use of present-day technology, such as smart phones and tablets, in the Dulles Metrorail Corridor Project, and the ability to virtually group members made the sharing of photos, videos, and other relevant information an instantaneous process. The project communication plan allowed the project manager to maintain control of the project and ensure that all stakeholders received the necessary information.
- The risk management plan was based on risk identification and on a detailed analysis on probability and impact used to evaluate the importance of each risk to subsequently classify them according to their priority and quantify them analytically and strategically. This risk management plan provides Bechtel Corporation a guide to measure and prioritize their risk potentials and the opportunities through logic impact scales aligned to project circumstances regarding the economic impact and project budget limitations. Bechtel Corporation's many years in the delivery of projects has reinforced their need to properly plan for risk management. The risk management plan encompassed a contingency

budget, molding pre-determined responses to problems and opportunities; the lessons learned to be shared with future projects; and lastly, due to the proper managing of unforeseen risks, an increase in the return on investments.

- As a result of this procurement management plan, Bechtel Corporation will be able to have a formal document that includes all important aspects related to procurement and contracts, but mainly, they will have a way to monitor and control vendor performance. The procurement management plan will provide Bechtel Corporation a tool to qualify their vendors, which will directly result in better project quality and positive results. This plan proves that project management is a collaborative effort that extends to management, the project team, contractors, vendors, and clients working on a project. As the project management incorporation of Bechtel Corporation expense projects matures, the connections between organizational project management and business value will become clearer and the project's performance will be outstanding.
- Project management is a collaborative effort that extends to management, the project team, contractors, vendors, and clients working on a project. As the project management incorporation of Bechtel Corporation expense projects matures, the connections between organizational project management and business value will become clearer, and the project's performance will be outstanding. The stakeholder management plan provides Bechtel Corporation the knowledge to envision actions that the stakeholders can undertake to create value either by their direct action into the project or by the influence they may have towards it. Project management is a collaborative effort that extends to the management of the organization, project team, contractors, vendors, and government and non-government ministries, all working together on a project, more than 2,000 people, most of them from the Washington, D.C. area, who were contracted with more than 200 local businesses over the course of

the project. This stakeholder management plan emphasizes the relationship between the organizations, Bechtel Corporation, the project team, procurement teams and contractors, and government and non-government ministries, in executing the project deliverables and improving the project performance. The stakeholder management plan provides the project manager with the methodology to ensure the stakeholders are effectively involved in project decisions and execution throughout the lifecycle of the project. Additionally, the stakeholder management plan helps to gain support for the project and anticipate resistance, conflict, or competing objectives among the project stakeholders.

CHAPTER VI. RECOMMENDATIONS

> The Dulles Corridor Metrorail is among the world's most sophisticated rail systems and boasts the latest safety features, such as advanced control systems. Passengers can expect one of the smoothest train rides ever experienced as a result of innovative design and construction. This construction includes five stations, 6 miles (nearly 10 kilometers) of elevated track, and twin tunnels running beneath one of the busiest office and retail centers in the United States—where 700,000 cars travel each day. Betchel Corporation employed more than 2,000 people, most of them from the Washington, D.C., area, and contracted with more than 200 local businesses over the course of the project. (Bechtel Corporation, n.d.c. para. 3)

This project management plan was created using the analytical research method and the 6th edition of the PMBOK® Guide (PMI, 2017), and is intended to be the main source of comprehensive information for improving the overall project performance success rate and protecting their competitive advantages as promoted by Bechtel.

Betchel Corporation values each project as a non-recurring, time-limited, and budgeted commitment entity, and the aim is to provide the most value every time. The company recognizes that collaborating with its partners, listening to their needs, and acting in their best interests is what is expected.

The project management plan recommends the federal transit administrator to carry out the following actions:

- Verifying that valid criteria exist to determine the lateral load capacity of the existing foundations with analyses that are based on the assumed, non-tested, capacity of piles, and providing oversight to ensure that the Metropolitan Washington Airports Authority executes any resulting changes to the analyses, design, and testing requirements
- Developing and implementing a plan, with milestones, to ensure that the Metropolitan Washington Airports Authority carries out appropriate stray

current tests to calculate the piles' corrosion rate and estimate their remaining years of service. Specifically:

  - Measuring the maximum stray current density with steel coupons installed vertically at multiple depths adjacent to the pile(s) selected for testing and using the current measured densities to calculate the steel corrosion rate
  - Establishing the thresholds for the stray current density and corrosion rate that will achieve the desired service life and calculating the remaining service life for the old foundations
  - Testing the track-to-earth resistance to establish baseline conditions concurrently with the stray current density
  - Using the track-to-earth resistance and stray current density test results to design the corrosion protection measures that meet the service life goal
- Developing and implementing a plan, with milestones, to ensure that the Metropolitan Washington Airports Authority installs any applicable corrosion protection measures that emerge from the stray current tests before the Washington Metropolitan Area Transit Authority accepts the final Dulles project
- Requiring the Metropolitan Washington Airports Authority to resolve potential schedule delays by finalizing the Washington Metropolitan Area Transit Authority's rail fleet management plan to ensure that sufficient railcars will be available for the silver line, without negatively impacting metrorail service on other lines
- Requiring the Metropolitan Washington Airports Authority to resolve potential schedule risks by working with the Metropolitan Washington Airport Authority and its contractor to make a final determination as to whether the full scope of the West Falls Church Yard expansion is accounted for and falls within phase 1 of the Dulles project's critical path, and if so, properly adjusting the project schedule and cost to reflect this

- Requiring the Metropolitan Washington Airports Authority to resolve potential funding risks by funding the $200 million for the capital reserve account
- Finalizing the Metropolitan Washington Airports Authority's risk and contingency management plan to ensure mitigation plans are in place to address cost risks
    - The integration management plan will contribute to the acceleration of Bechtel Corporation's competitive advantage by aligning its project management strategies directly with their strategic business and by creating and managing the link between strategy and results. The project charter creation gives Bechtel Corporation's management and its stakeholders a formal way to be able to share a common understanding of why the project is being done, the timeframe, deliverables, risks, assumptions, boundaries, and responsibilities, and since it is approved by the sponsor, it provides the project the importance it requires to be managed and executed successfully. The leveraging experience, best practices, and lessons learned, also included in the integration management plan, will support the Bechtel Corporation's management oversight to cut costs and sidestep risks in Bechtel Corporation's projects, enabling them to implement stronger project management practices for the future.
    - Trying to introduce any type of structure or control in an organization or environment that has been absent of controls, such as in Bechtel Corporation's case, can present a significant challenge. Poorly managed change control has a negative influence on the customer's expectations, cost variances, schedule variances, team morale, resource management, and so on. They are inseparable from perceptions of a project's success. This scope management plan will provide Bechtel Corporation significant guidance towards the scope

change process, requirements, limitations, and the accountability of the project manager and sponsor towards any change approval.

- Since this project is time sensitive, critical path activities and the schedule cost baseline determination are two major advantages of the schedule management plan. Bechtel Corporation will be able to measure the project's progress against a formal base to ensure keeping track and managing it in a controlled way through the project lifecycle.
- A major benefit resulting from the cost management plan was the identification of a cost baseline. Bechtel Corporation will be able to measure and report the project's progress against a formal base to ensure keeping track and managing it in a controlled way through the project lifecycle.
- The way to get the most value out of a project management methodology is through metrics tied to business goals, collecting the data, and making it available to everyone. The quality management plan provides Bechtel Corporation the guidance for keeping the project on track and extending those metrics across the project team and out to suppliers, contractors, the client, and the stakeholders.
- One of the biggest challenges for Bechtel Corporation's "expense projects" has been their resource limitation, since they share resources with the projects related to capital generation. The resource management plan provides Bechtel Corporation the way to better allocate and organize the resources needed when they are needed and to justify the additional allocation of funds for additional resources to assist in the project, if necessary.
- The payoff from investing time, money, and resources into Bechtel Corporation's expense projects will be justified with the controlled and monitored results to be obtained in the regular occurring meetings included in the communication management plan. Those regular meetings will also develop the innovation within the team, since they

will be able to have forums to provide solutions and ideas that will lead to increased productivity, profitability, and project success.

- The risk management plan was based on risk identification and on a detailed analysis on the probability and impact used to evaluate the importance of each risk to subsequently classify them according to their priority and to quantify them analytically and strategically. This risk management plan provides Bechtel Corporation a guide to measure and prioritize their risk potentials and the opportunities through logic impact scales aligned to project circumstances regarding the economic impact and project budget limitations.
- As a result of this procurement management plan, Bechtel Corporation will be able to have a formal document that includes all important aspects related to procurement and contracts, but mainly, they will have a way to monitor and control vendor performance. The procurement management plan will provide Bechtel Corporation a tool to qualify their vendors, which will directly result in better project quality and positive results. This plan proves that project management is a collaborative effort that extends to management, the project team, contractors, vendors, and clients working on a project. As the project management incorporation of Bechtel Corporation's expense projects matures, the connections between organizational project management and business value will become clearer, and project's performance will be outstanding.
- Project management is a collaborative effort that extends to management, the project team, contractors, vendors, and clients working on a project. As the project management incorporation of Bechtel Corporation's expense projects matures, the connections between organizational project management and business value will become clearer, and project's performance will be outstanding. The stakeholder management plan provides Bechtel Corporation the knowledge to envision actions that stakeholders can undertake to

create value either by their direct action into the project or by the influence they may have towards it.

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APPENDICES

Appendix 1: FGP Charter

PROJECT CHARTER	
Date:	**Project name:**
June 20, 2020	PROJECT MANAGEMENT PLAN FOR THE RAILWAY LINE EXTENSION IN WASHINGTON, D.C.
Knowledge areas / PM processes:	**Application area (sector / activity):**
Knowledge areas: Project integration Project scope Schedule Cost Quality Resources Communication Risks Procurement Stakeholders	Project planning Construction management Communication management Large scale construction Phase level multi city construction
Project start date:	**Project finish date:**
June 20, 2020	January 10, 2021
Project objectives (general and specific):	
PROJECT MANAGEMENT PLAN FOR THE RAILWAY LINE EXTENSION IN WASHINGTON, D.C.	
General objective:	
To develop a project management plan, as per the standards of the Project Management Institute (PMI), that integrates sustainable principles to optimize the utilization of project resources during the construction of the extension of the metrorail to Dulles International Airport and Loudoun County.	
Specific objectives:	
The specific objectives of the project management plan are done in order: 1. To create a sustainable scope management plan that identifies key stakeholders and their specific obligations and opportunities 2. To create a balanced schedule management plan to assign duration to work packages that can be tracked 3. To create a balanced cost management plan to allocate costs to work packages 4. To create a sustainable quality management plan to define the minimum stakeholder acceptance criterion 5. To create a communication management plan to allocate resources to work packages in a manner that is consistent with international law and labor conventions 6. To create a sustainable communication management plan to clearly define the communication strategy of the project and the reporting authorities 7. To create a sustainable risk management plan that identifies risks and risk responses that are directly related to the project and affect sustainability 8. To create a sustainable order/procurement management plan to identify and assign contracts to suppliers who can obtain sustainable goods and services	

9. To create a stakeholder management plan that identifies key stakeholders and their interests and analyzes how their impact can affect the project

Project purpose or justification (merit and expected results):

The purpose of developing a project management plan is to integrate sustainable principles in order to effectively carry out project management activities so that the Dulles metrorail construction can be completed within the planned functional scheduled timeframe, with the desirable quality, and within budget. Just like every other project area, construction projects may fail for several reasons. There is no single method or organizational structure that can be used to manage projects to success. Project failure can happen in any organization and to any project. There is an infinite number of reasons for failure. Sometimes, failure is controllable. To overcome failure for this massive project, the “project management plan” is created.

The goal of project management is to produce a successful construction and not be hindered by the errors of omission as well as commission by management, project managers, team members, and others associated with the projects. The purpose of this project management plan is to enable the identification of the common causes of project failures through the use of surveys to collect information that can be used to mitigate occurrence and in many cases, repair the damage caused and recover the project.

The project management plan is created in order:

a. To create a project management plan that integrates sustainable principles to effectively carry out project management activities
b. To provide planning for an outcome of high-quality and high-capacity transit service in the Dulles Corridor
c. To improve public involvement notices and support the collaboration for local people, business owners, and press meetings
d. To improve internal communication, coordination, and streamline decision-making. Integrate [resources] across all phases of project delivery.

Description of product or service to be generated by the project – project final deliverables:

The final graduation project (FGP) will provide everything necessary regarding a project management plan following the good practices established by the PMBOK 6th Edition. This will include the following: 1. project charter, 2. scope management, 3. scheduled plan, 4. resource management plan, 5. communication management plan, 6. stakeholder management, 7. procurement management plan, and 8. risk management plan.

Assumptions:

An assumption is what you believe to be true. They are anticipated events or circumstances that are expected during your project’s life cycle. You make assumptions based on your experience or the information available on hand.

Assumptions may not end up being true. Sometimes, they can be false, and it may affect your project. This adds risk to the project.

Constraints:

Constraints are limitations imposed on the project: for example, budget, schedule, or resources, etc. The PMBOK Guide (PMI, 2017) recognizes six project constraints: scope, quality, schedule, budget, resources, and risk. Out of these six, scope, schedule, and budget are known as the triple constraints.

These constraints are defined at the beginning of your project. And you must work within their boundaries.

A constraint can be of two types:
a. Business constraints
b. Technical constraints

Preliminary risks:

1-The cost of the project is expected to go higher depending on the construction phases and environmental factors.
2- There are multiple teams and associated members and stakeholders. The project manager's ability to track the resources and outline the project planning may be delayed considering these factors.
3-The project can be more difficult to execute than expected.
4-This is a large-scale project , and its timeline can be extended depending on its development.

Budget:

The project budget and the established cooperative process total project estimate is $44.5M (org.$56.7M) in phase 1, and the total project estimate is $52M (org. $57M) in phase 2.

Milestones and dates:

Milestone	**Start date**	**End date**
Start of the final graduation project	June 20, 2020	July 25, 2020
Graduation seminar	June 20, 2020	July 25, 2020
Tutoring process	September 5, 2020	January 10, 2021

Relevant historical information:

For the development of the final graduation project, the primary information sources will be considered from several primary approaches that will be used as main sources from the Dulles Corridor Metrorail Project. (n.d.a). Published in December 2004 and the Federal Transit Administration (FTA) Issued Its Record of Decision Approving the Environmental Process in March 2005. Primary sources may also include surveys, interviews, observations, research, historical and legal documents, financial data published in the Dulles metrorail website, accounts, experiment results, statistical data, pieces of creative writing, audio and video recordings, speeches, art objects, Internet searches, fieldwork, and Internet communication via email, blogs, and newsgroups.
Dulles Transit Partners LLC (DTP) selected Bechtel Infrastructure Inc. and Washington Group International (now URS) to construct phase 1 and phase 3 of the 11.6-mile project. DTP is a joint venture. Bechtel has been selected by the Metropolitan Washington Airports Authority (MWAA) to submit a proposal to design and build phase 2 of the Dulles Corridor Metrorail Project. Phase 2 will provide rail service between Washington, D.C. and Washington Dulles International Airport. The Washington Metropolitan Area Transit Authority (WMATA), Fairfax County, Loudoun County, the town of Herndon, and the Metropolitan Washington Airports Authority (MWAA) are partners in this 23-mile transit extension in the rapidly growing Dulles Corridor in Fairfax and Loudoun Counties, Virginia.

Stakeholders:

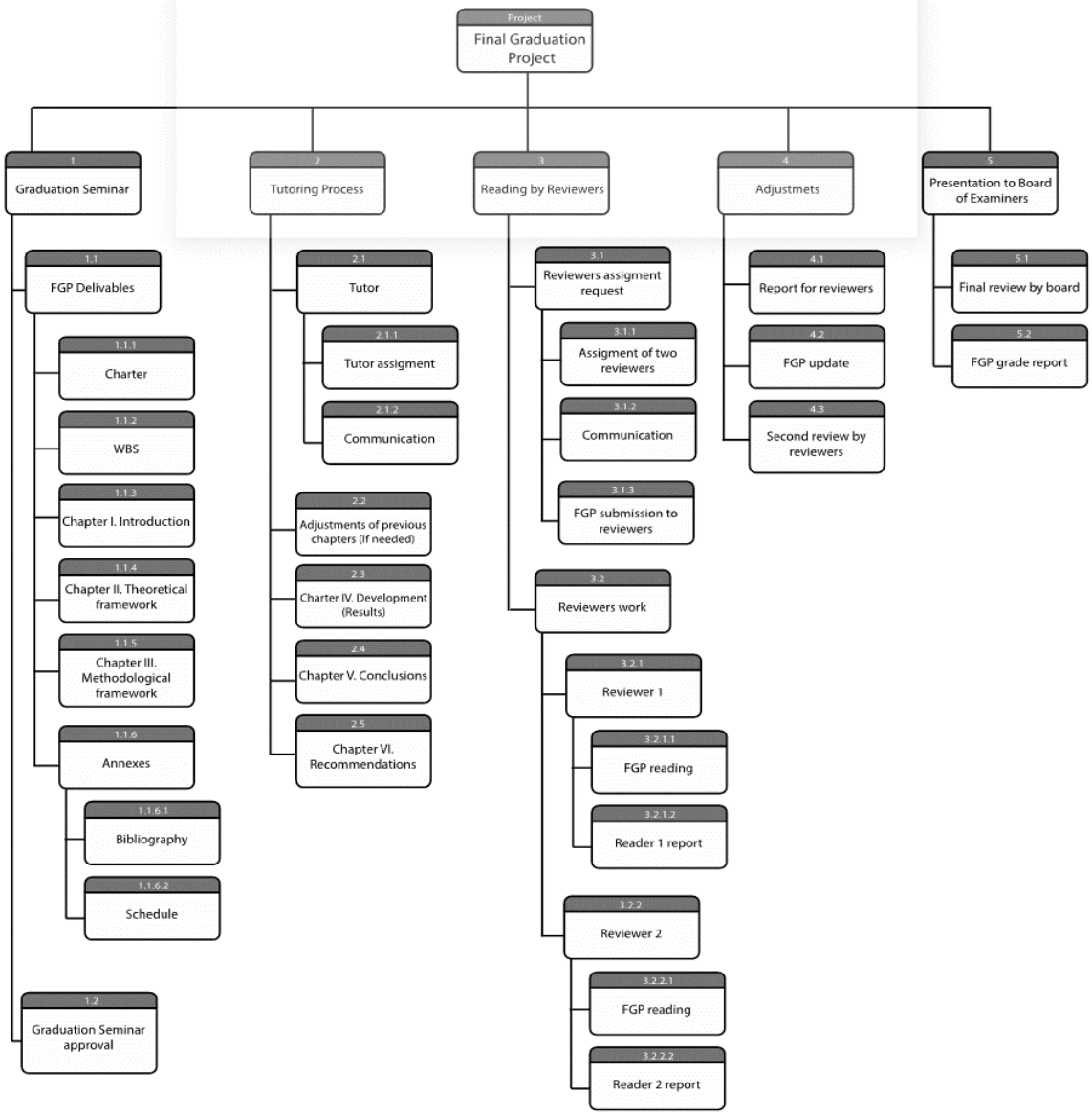
Federal transit administration of the U.S. Department of Transportation
Local news channels and reports
Environmental activists, NGO's
Project and construction management of the WA Airports Authority
WA railway dept
Airport agency
Transit partner engineering dept
Construction department

Approval:

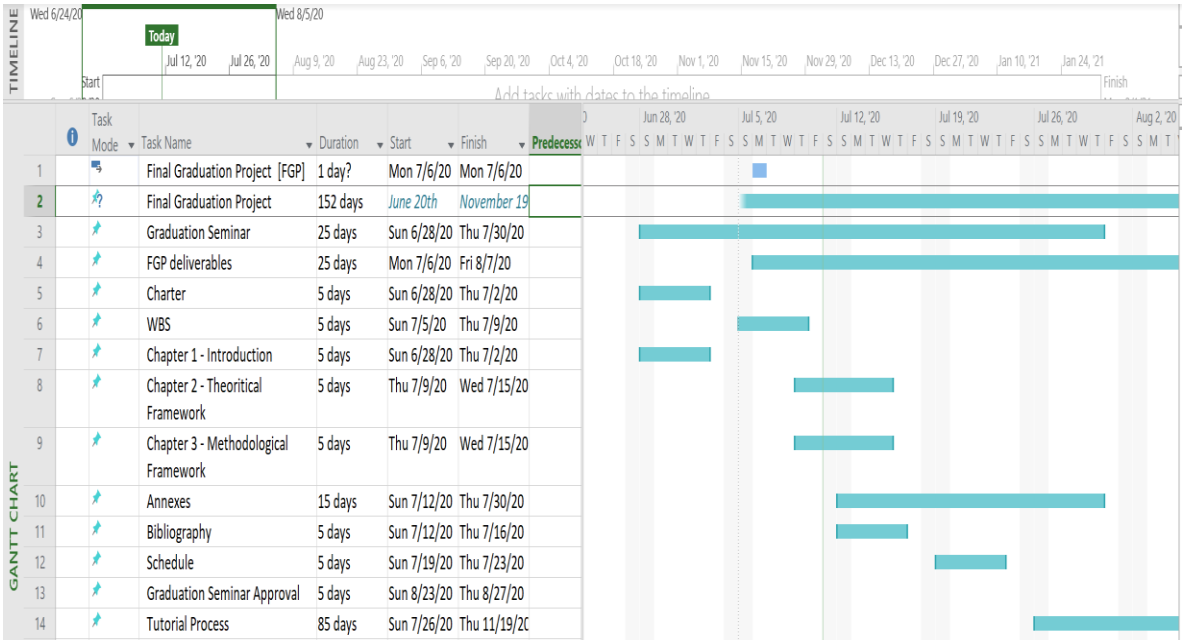
Project Manager:	Signature: Nikita Saran

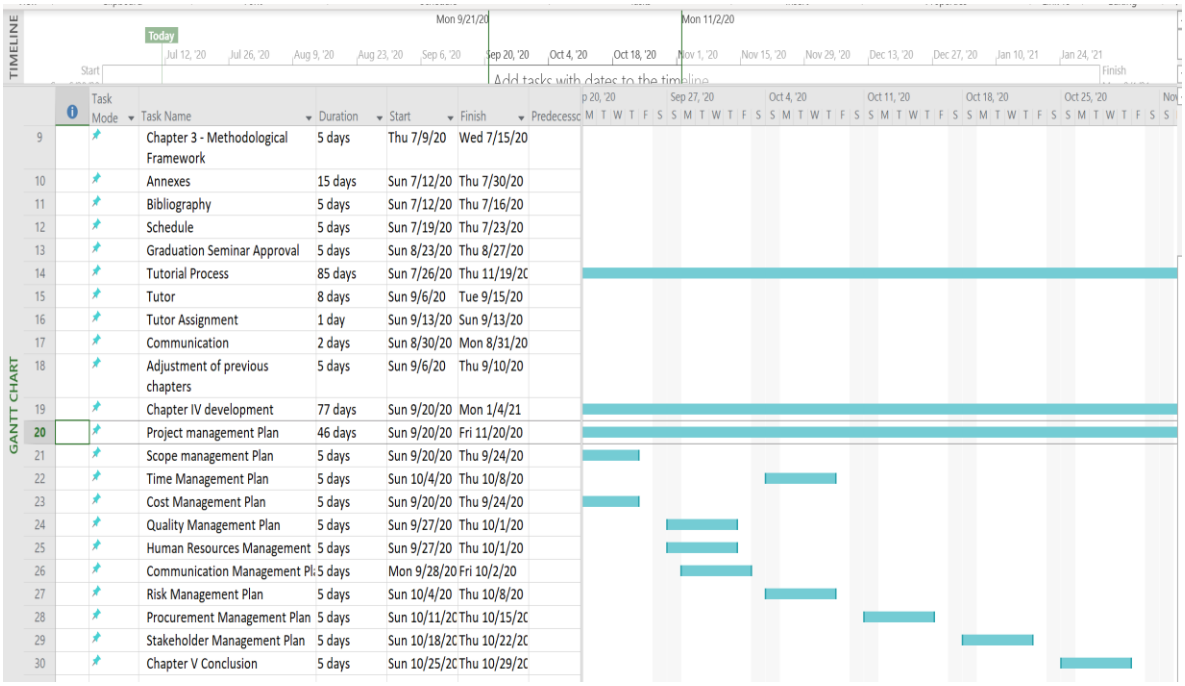
	
Authorized by:	Signature:

Appendix 2: FGP WBS

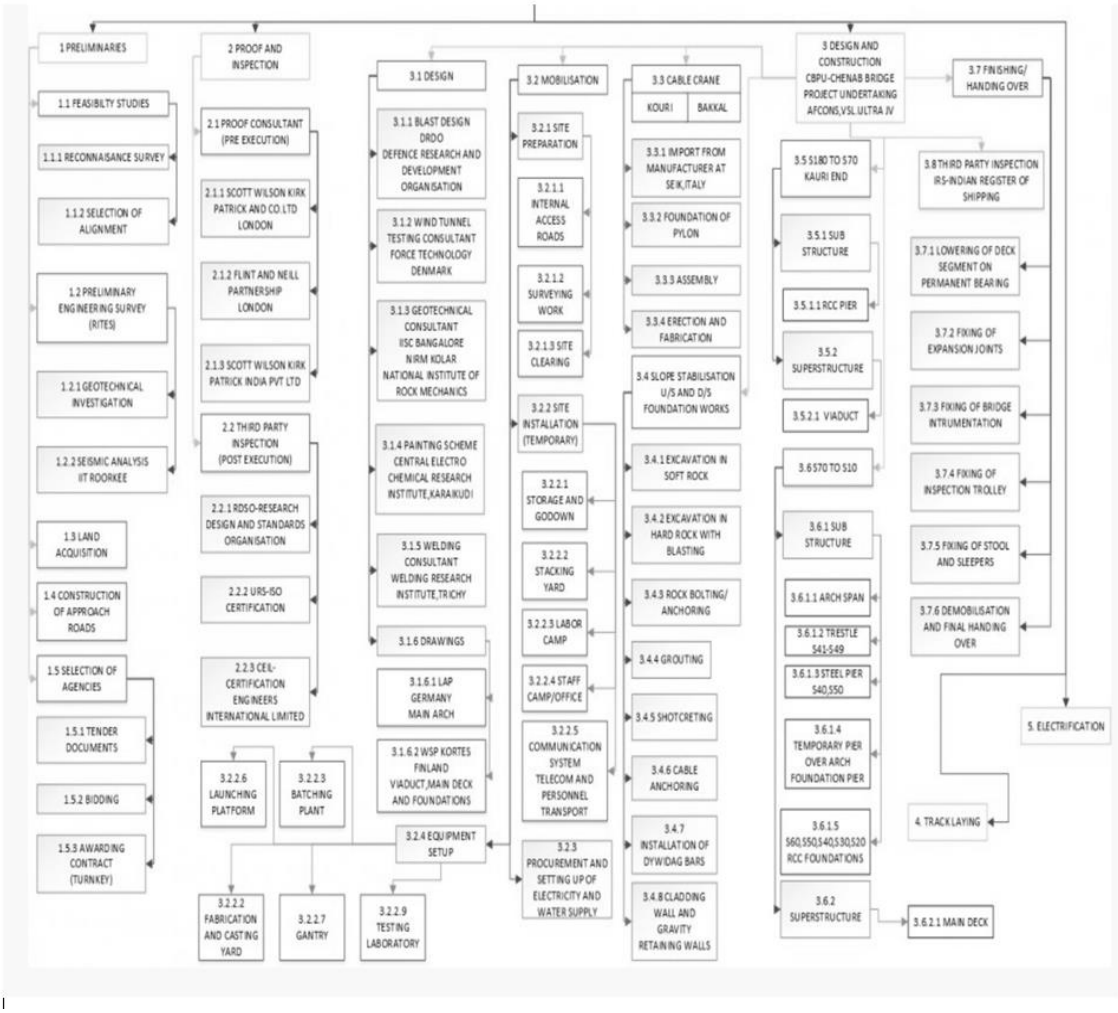


Appendix 3: FGP Schedule





Railway Construction Plan



Appendix 4: Proofreading letter

San José, December 14, 2020

Universidad para la Cooperación Internacional (UCI)

To Whom It May Concern:

Natalia Alvarado Mata, identification number 305030705, Bachelor in English with a focus on translation, hereby states that the project titled: **PROJECT MANAGEMENT PLAN FOR THE RAILWAY LINE EXTENSION IN WASHINGTON, D.C.**, carried out by Nikita Saran, has been revised.

The project was carried out to obtain the **Master in Project Management (MPM)** Degree. Aspects such as paragraph form, language quirks in written language, orthography, punctuation, and other aspects related to syntax and grammar were inspected and proofread. Therefore, taking into account the changes that were made, the project is ready to be presented.

Sincerely,

Natalia Alvarado

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Natalia Alvarado Mata
English Translator and Proofreader
natalia.alvarado@filologos.cr

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